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PRELIMINARY
INSTRUCTION MANUAL

MODEL 160

DIGITAL MULTIMETER

KEITHLEY INSTRUMENTS

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, DDD 216-248-0400. You will be given assistance and shipping instructions.

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KEITHLEY INSTRUMENTS, INC.

PRELIMINARY INSTRUCTION MANUAL

MODEL 160

DIGITAL MULTIMETER

This Preliminary Instruction Manual is supplied to permit earliest possible delivery of your instrument.

It contains Specifications, Operation instructions, Circuit Description, Replaceable Parts List and Schematics. The Final Edition will contain Servicing and Calibration information to maintain the instrument.

Please detach, fill out and return the Warranty Card attached to the instrument so that the Final Edition Instruction Manual can be sent to your attention. If you have further questions, please contact your Keithley Representative or the Sales Service Department.

Product Literature Department

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Specifications

AS A DC VOLTMETER
RANGE: ±1 microvolt per digit to ±1000 volts full scale in seven decade ranges. 100% overranging on all except the 1000-volt range.
ACCURACY: ±0.1% of reading, ±1 digit on all ranges.
INPUT RESISTANCE: 10 megohms on the 10-millivolt and higher ranges, 1 megohm on the 1-millivolt range.
AC REJECTION:
NMRR: Greater than 80 dB above one digit for a voltage of line frequency or twice line frequency on the most sensitive range, decreasing to 60 dB on the 100-millivolt and higher ranges. 1000 volts peak-to-peak maximum.
CMRR: Greater than 120 dB above one digit at dc and 40 to 100 Hz ac. 500 volts dc, 100 volts peak-to-peak ac maximum.
SETTLING TIME: Less than 2 seconds to rated accuracy.
MAXIMUM OVERLOAD: 1000 volts continuous input on 1-volt to 1000-volt ranges. 1000 volts momentary, 300 volts continuous on lower ranges.

AS A DC AMMETER: (Model 160 only)
RANGE: ±0.1 nanoampere per digit to ±1 ampere full scale in eight decade ranges. 100% overranging on all ranges.
ACCURACY: ±0.2% of reading, ±1 digit on the 100-nanoampere to 10-milliampere ranges, ±0.3% of reading, ±1 digit on the 0.1 and 1-ampere ranges.
INPUT RESISTANCE: 100 kilohms on the 0.1-microampere range, decreasing to 0.1 ohm on the 100-milliampere and 1-ampere ranges.
NMRR: 60 dB above one digit for a current of line frequency or twice line frequency.
MAXIMUM OVERLOAD: 50 times full scale continuous on all ranges up to a maximum of 3 amperes.

AS AN OHMMETER: (Model 160 only)
RANGE: 0.1 ohm per digit to 1000 megohms full scale in eight decade ranges. 100% overranging on all ranges.
ACCURACY: ±0.3% of reading, ±1 digit, ±0.1 ohm on the 100-ohm to 1-megohm ranges, decreasing to ±10% on the 100-megohm range. The 1000-megohm range is intended for relative resistance measurements only (±50%).
VOLTAGE ACROSS UNKNOWN: 100 millivolts at full scale, 1.5 volts maximum into an open circuit.
MAXIMUM OVERLOAD: 20 volts momentary, 1 volt continuous.

GENERAL
ANALOG OUTPUT: ±1 volt dc at up to 1 milliampere for full scale input, 100% overranging on all ranges except the 1000-volt range.
POLARITY: Automatic.
ZERO STABILITY: ±0.3 microvolt/°C, ±2 microvolts/day after 1-hour warm-up.
OFFSET CURRENT: Typically less than 10 picoamperes.
ACCURACY STABILITY: ±0.01%/°C (±0.06%/°C on ohms). Accuracy (rated at 23°C ambient after a 30-minute warm-up) is maintained for at least 6 months.
DISPLAY: 3 digits plus 1 overrange digit; polarity and overload indication; 2 readings per second.
ISOLATION: Circuit ground to chassis ground: greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.
POWER: 105-125 or 210-250 volts (switch selected), 50 or 60 Hz, 20 watts.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL.

a. The Keithley Model 160 is a completely solid-state, line operated multimeter with the accuracy and convenience of a digital display. It has seven d-c voltage ranges from 1 millivolt full scale to 1000 volts full scale with 100% overranging on every range except 1000 volts. The Model 160 also measures from 100 nanoamperes full scale to 1 ampere with 100% overranging on each range. The ohms ranges are from 100 ohms full scale to 1000 megohms also with 100% overranging.

b. The Keithley Model 163 is a Voltmeter-Only version of the Model 160 Digital Multimeter. It has all the main features of the Model 160 except the ammeter and ohmmeter functions are deleted.

c. With the use of Keithley Model 1601 AC/DC Probe, a-c measurements can be made from 0.1 volt to 250 volts rms over a span of 45 Hz to 45 kHz. A probe-mounted switch provides convenient selection of a-c or d-c operation without disconnecting the probe.

1-2. FEATURES.

a. Accuracy is ±0.1% ±1 digit on any voltage range.

b. Input is protected for ±1000 volts continuous input on 1-volt to 1000 volt ranges. Rated at ±300 volts continuous input on 1 millivolt range.

c. Zero stability is ±2 microvolts/day after one hour warmup.

d. Single RANGE Control is designated in convenient engineering units.

e. Circuit low to chassis ground isolation permits safe off-ground measurements up to ±500 volts.

f. Instrument operates from either 50 or 60 Hz, 117 or 234 volt power.

g. Convenient recorder output is ±1 volt at 1 milliampere.

h. Model 1602 Digital Output Kit provides optional BCD Output.

1-3. APPLICATIONS. The Model 160 is a general purpose instrument - used in Basic Research, Electronics Development, and Process Control.

1. In the Research Lab - When used with a suitable probe, transducer, or electronic circuit, Model 160 can be used to indicate digitally, volts, amps, or ohms, or through conversion, any physical parameter such as temperature, pressure, rpm, etc.

2. In Electronics Development Activity - Useable for basic electrical measurements of voltage, current, or resistance. Especially suited for in-circuit resistance measurements.

3. In Process Control Activity - Adaptable for OEM equipment where repetitive measurements are needed with analog or digital printout.

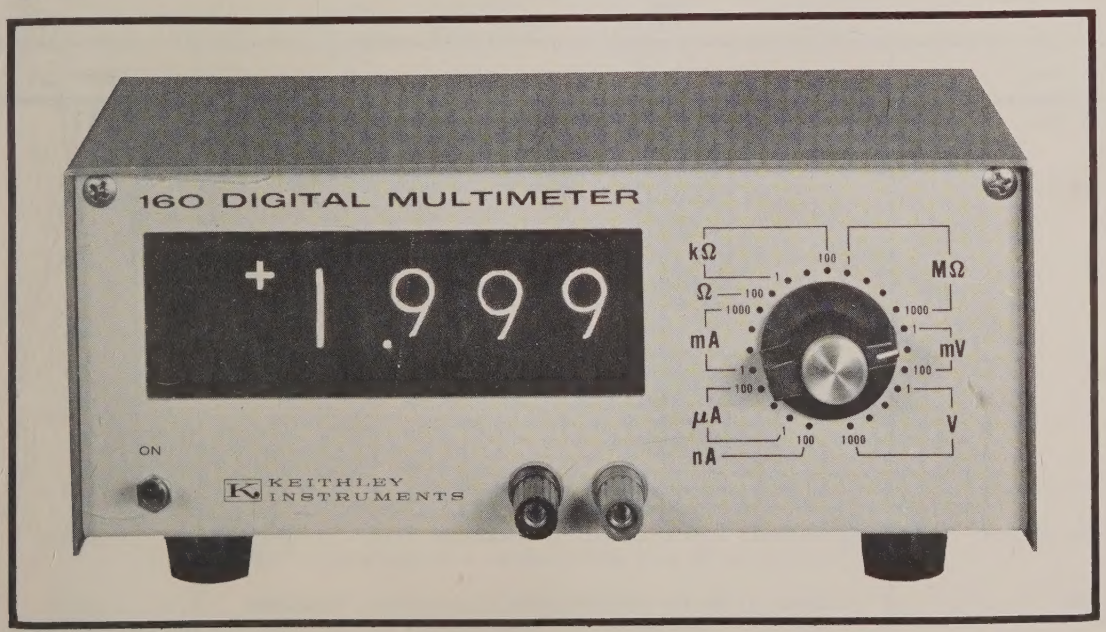


FIGURE 1. Model 160 Digital Multimeter - Front Panel

TABLE 1-2.

Front Panel Controls and Terminals. (Refer also to Figure 2). This Table briefly describes the function of the controls and terminals on the front panel. The paragraph indicated describes in detail the operation of the controls.

Control	Functional Description	Paragraph
Range Switch	Selects the full scale range and parameter to be measured (volts, amperes, or ohms).	2-2
Power Switch	Controls a-c line power to instrument (ON/OFF).	2-2
High Terminal (Red)	Connects input high to signal source.	2-1
Low Terminal (Black)	Connects input low to signal source. Circuit low is connected to chassis ground when the rear panel LO Switch is in the GND position. For floating operation, set the LO Switch to FLOAT.	2-1
Polarity Indicator	Indicates polarity of the input signal.	2-2
Numerical Readout	Indicates magnitude of input signal.	2-8

TABLE 1-3.

Rear Panel Controls and Terminals. (Refer also to Figure 3). This Table briefly describes the function of the controls and terminals on the rear panel. The paragraph indicated describes in detail the operation of the controls.

Control	Functional Description	Paragraph
AC POWER Cord 50-60 Hz	Connects a-c line power to instrument.	2-4
117V-234V Switch	Sets instrument for either 117 or 234V a-c line power.	2-3
LO Switch	Sets the instrument for normal or floating operation. In GND position the chassis ground and circuit low are connected. In FLOAT the circuit low is not connected to chassis ground. Isolation from circuit ground to chassis ground is greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.	2-3
ZERO Control	Screwdriver adjustment for fine zero.	2-3
OUTPUT Receptacle	Connects analog output to recording device. Output is ±1 volt d-c at up to 1 milliampere.	2-10
BCD OUTPUT	Cover plate for PRINTER/CONTROL connector furnished only with optional Model 1602 Digital Output Kit.	2-12

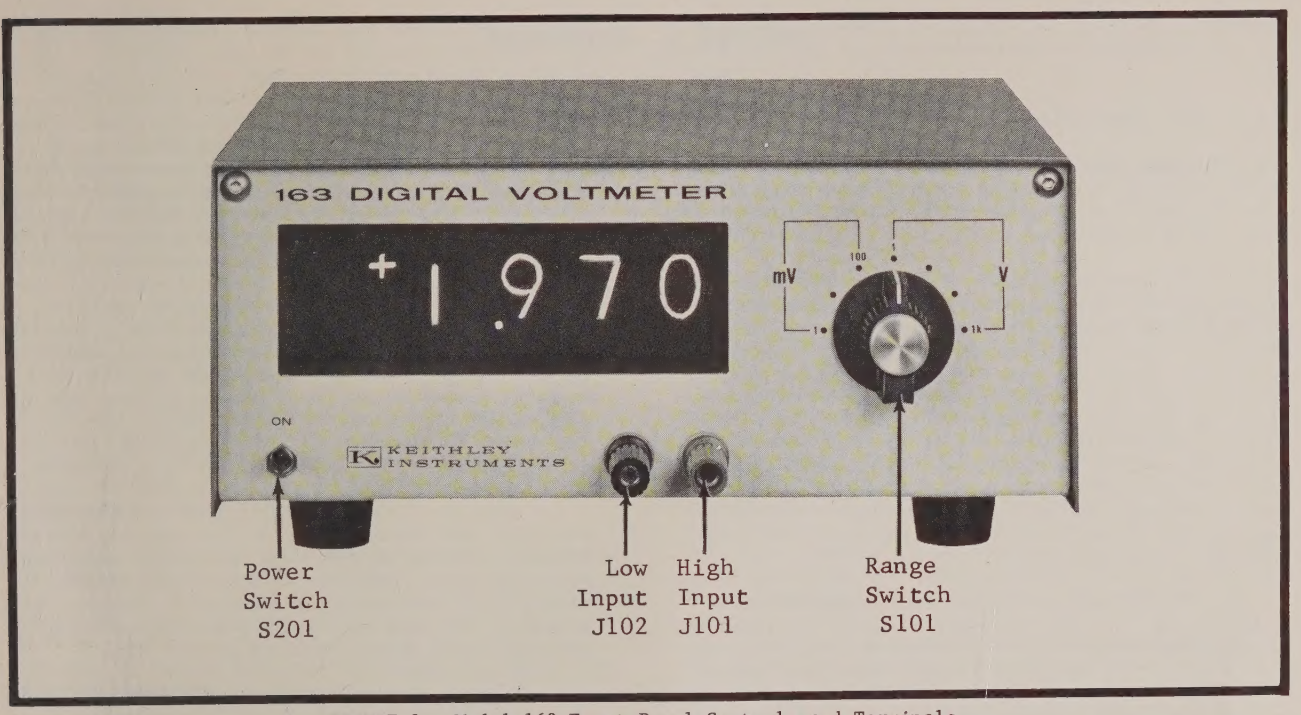


FIGURE 2. Model 163 Front Panel Controls and Terminals.

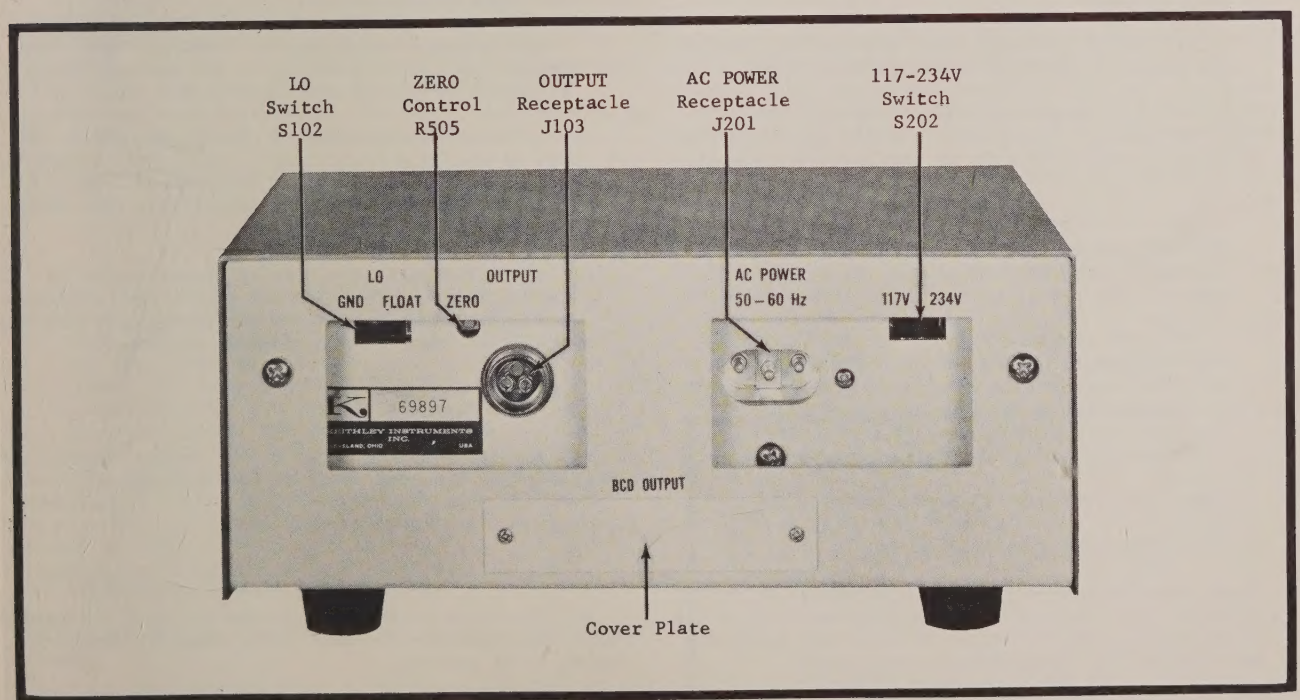


FIGURE 3. Model 160, 163 Rear Panel Controls and Terminals.

SECTION 2. OPERATION

2-1. INPUT CONNECTIONS.

a. Binding Post Terminals. Two binding posts are provided on the front panel for all input connections. The terminals are color coded as follows: Red = Input High, Black = Input Low.

b. Noise Considerations. The limit of resolution in voltage and current measurements is determined largely by the noise generated in the source. Stray low-level noise is present in some form in nearly all electrical circuits. The instrument does not distinguish between stray and signal voltages since it measures the net voltage. When using the 1 mV and 10 mV ranges, consider the presence of low-level electrical phenomena such as thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (dielectric absorption), and battery action of two terminals (galvanic action).

1. Thermal EMFs. Thermal emfs (thermoelectric potentials) are generated by thermal differences between two junctions of dissimilar metals. To minimize the drift caused by thermal emfs, use copper leads to connect the circuit to the instrument. The rear panel ZERO control can be used to buck out a constant thermal offset voltage if necessary. The Keithley accessory Model 1483 Low Thermal Connection Kit contains all necessary materials for making very low thermal copper crimp connections for minimizing thermal effects.

2. A-C Electric Fields. The presence of electric fields generated by power lines or other sources can have an effect on instrument operation. A-C voltages which are very large with respect to the full-scale range sensitivity could drive the a-c amplifier into saturation, thus producing an erroneous d-c output.

NOTE

The instrument provides attenuation of line frequency noise superimposed on an input signal. The a-c rejection is specified as follows:

NMRR: Greater than 80 dB above one digit for a voltage of line frequency or twice line frequency on the most sensitive range, decreasing to 60 dB on the 100-millivolt and higher ranges. 1000 volts peak-to-peak maximum.
CMRR: Greater than 120 dB above one digit at dc and 40 to 100 Hz ac. 500 volts dc, 100 volts peak-to-peak ac maximum.

Proper shielding as described in paragraph 2-1,c can minimize noise pick-up when the instrument is in the presence of large a-c fields or when very sensitive measurements are being made.

3. Magentic Fields. The presence of strong magnetic fields can be a potential source of a-c noise. Magnetic flux lines which cut a conductor can produce large a-c noise especially at power line frequencies. The voltage induced due to magentic flux is proportional to the area enclosed by the circuit as well as the rate of change of magnetic flux. For example, the motion of a 3-inch diameter loop in the earth's magnetic field will induce a signal of several tenths of a microvolt. One way to minimize magnetic pickup is to arrange all wiring so that the loop area enclosed is as small as possible (such as twisting input leads). A second way to minimize magnetic pickup is to use shielding as described in paragraph 2-1, c.

c. Shielding.

1. Electric Fields. Shielding is usually necessary when the instrument is in the presence of very large a-c fields or when very sensitive measurements are being made. The shields of the measurement circuit and leads should be connected together to ground at only one point. This provides a "tree" configuration, which minimizes ground loops.

2. Magnetic Fields. Magnetic shielding is useful where very large magnetic fields are present. Shielding, which is available in the form of plates, foil or cables, can be used to shield the measuring circuit, the lead wires, or the instrument itself.

3. Other Considerations.

a) Voltmeter Measurements. Use shielded input leads when source resistances are greater than 1 Kilohm or when long input cables are used.

b) Current Measurements (Model 160 only). On the mA and μA current ranges, no special shielding precautions need be taken. However, on the 100 nanoampere range, shielded input leads are recommended.

c) Resistance Measurements (Model 160 only). Shielding of input leads and source are recommended for measurements on the 10 megohm through 1000 megohm ranges to prevent erroneous readings

2-2. FRONT PANEL CONTROLS.

a. The Power Switch is an ON/OFF toggle switch that controls the a-c line power to the instrument.

NOTE

The Polarity Indicator serves as a pilot light.

b. The Range Switch is a convenient single T-handle knob that controls the full scale range of the parameter to be measured.

1. The Range Switch dial is labeled in engineering

units for voltage, current, and resistance, that is mV, V (Voltage), nA, μA, mA (Current) and Ω, kΩ, MΩ (Resistance). For each parameter, rotating the knob clockwise switches to the less sensitive range.

2. The voltage sectors of the Range Switch are designated in millivolts (mV) and volts (V) for full scale ranges from 1 millivolt to 1000 volts. A full stop at the 1000 volt range prevents inadvertant switching to the nanoampere ranges with clockwise switch rotation.

3. The resistance (ohms) sectors of the Range Switch (Model 160 only) are designated in ohms (Ω), kilohms (KΩ), and megohms (MΩ) for full scale ranges from 100 ohms to 1000 megohms.

4. The current (amperes) sectors of the Range Switch (Model 160 only) are designated in nanoamperes (nA), microamperes (μA), and milliamperes (mA), for full scale ranges from 100 nanoamperes to 1000 milliamperes.

c. Digital Display. The digital display uses three full digits plus an overrange "1".

2-3. REAR PANEL CONTROLS.

a. The LO Switch sets the instrument for normal or floating operation.

1. With the LO Switch placed in the GND position, the input low is connected to case ground for normal operation.

2. With the LO Switch placed in the FLOAT position, the input low is disconnected from case ground for floating operation. Isolation from circuit ground to chassis ground is greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.

b. The 117-234 Volt Switch sets the instrument for either 117 or 234V rms a-c line power at 50 or 60 Hz.

NOTE

The front panel Power Switch is fused for both 117 and 234V operation. The fuses are installed on printed circuit board PC-254 and can be serviced by removing the top cover. The rear panel 117-234 Volt Switch connects either a 1/4 A (FU-33) or 1/2 A (FU-35) fuse for the selected line voltage.

c. The ZERO Control provides fine zero adjustment (usually required only for extreme changes of ambient temperature). This adjustment requires a screwdriver or similar tool.

2-4. PRELIMINARY OPERATING PROCEDURES.

a. Check the 117-234V Switch for the proper a-c line voltage.

b. Connect the line cord to either 117 or 234V a-c power line.

c. Set the Power Switch to ON. Allow a 30 minute warmup period for measurements on 10 mV and lower ranges.

2-5. VOLTMETER OPERATION.

a. The instrument can be conveniently used for d-c voltage measurements from ±1 microvolt to ±1000 volts by connecting the source to the front panel binding post terminals.

b. Overload Recovery. The instrument will recover from 300-volt overloads within five seconds on the 1 mV range. Up to 1000 volts peak may be applied momentarily on any range without damaging the instrument.

c. Input resistance is 10 megohms on the 10 millivolt and higher ranges, 1 megohm on the 1-millivolt range. For 10 mV and higher ranges, a 1000 ohm source resistance will introduce only 0.01% error. To maintain rated accuracy on the 1 mV range, the source resistance should not exceed 100 ohms.

d. The instrument low terminal can be floated ±500 volts above CASE ground for voltage measurements. Refer to paragraph 2-9 for complete instructions.

e. The Model 1601 AC/DC Probe permits convenient a-c voltage measurements from 0.1 volt to 250 volts rms over a span of 45 Hz to 45 kHz. A probe-mounted switch provides convenient selection of a-c or d-c operation without disconnecting the probe. Therefore, the probe may be permanently attached.

2-6. AMMETER OPERATION (Model 160 only).

a. The Model 160 can be conveniently used for d-c current measurements from ±0.1 nanoampere to ±1 ampere with 100% overranging on all ranges.

b. Connect the input terminals so as to place the Multimeter in series with the current to be measured.

c. The current accuracy is specified as ±0.2% of reading, ±1 digit on all ranges. Since the accuracy is specified at the input terminals, the loading effects as shown in Figure 4 should be considered. Refer also to Table 2-1 for resistance and sensitivity on each range.

d. The Model 160 low terminal can be floated ±500 volts above CASE ground for current measurements. Refer to paragraph 2-9 for complete instructions.

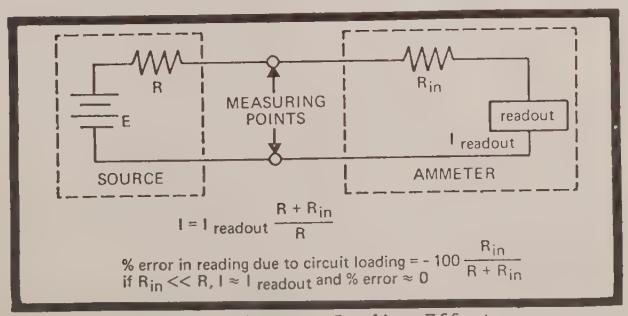


FIGURE 4. Ammeter Loading Effects.

TABLE 2-1.

Full Scale Range Amperes	Shunt Resistor Ohms (R_{in})	Sensitivity
1×10^{-7}	10^5	10 mV
1×10^{-6}	10^4	10 mV
1×10^{-5}	10^3	10 mV
1×10^{-4}	10^2	10 mV
1×10^{-3}	10	10 mV
1×10^{-2}	1	10 mV
1×10^{-1}	.1	10 mV
1	.1	100 mV

2-7. OHMMETER OPERATION (Model 160 only).

a. The Model 160 can be conveniently used for resistance measurements from 0.1 ohm to 2000 megohms by connecting the unknown resistor across the front panel binding post terminals.

b. Voltage across the unknown is 100 millivolts at full-scale with 1.5 volts maximum into an open circuit. Thus the current through the unknown is determined by dividing the 100 millivolts by the full scale resistance.

c. Maximum overload across the input terminals is 20 volts momentary and 1 volt continuous.

d. Accuracy is specified as shown in Table 2-2.

TABLE 2-2.

Full Scale Range	Decimal Point Position	Accuracy of Reading*
100 Ω	XX.X	±0.3% ±0.1 Ω
1 KΩ	.XXX	±0.3%
10 KΩ	X.XX	±0.3%
100 KΩ	XX.X	±0.3%
1 MΩ	.XXX	±0.3%
10 MΩ	X.XX	±0.3%
100 MΩ	XX.X	±10%
1000 MΩ	XXX	±50%

*(±1 digit on all ranges.)

2-8. DIGITAL DISPLAY OPERATION.

a. Voltmeter Digital Display.

1. When the Range Switch is placed in Voltage positions 1 mV through 1000V, the digital display indicates the actual voltage measured.

2. The Range Switch is designated in convenient engineering units, mV (millivolts) and V (volts) with the decimal point automatically positioned in the display.

3. The full-scale voltage range is determined by the Range Switch. Refer to Table 2-3 for the full-scale voltage ranges available.

TABLE 2-3.

Full Scale Range Volts	Decimal Point Position	Range Switch Designation
1×10^{-3}	.XXX	mV
1×10^{-2}	X.XX	mV
1×10^{-1}	XX.X	mV
1	.XXX	V
10	X.XX	V
100	XX.X	V
1000	XXX	V

4. An overrange display up to a maximum of 1999 is provided by an overrange "1" indicator as shown in Table 2-4.

NOTE

The maximum continuous input voltage is ±1000 volts on the 1000 volt range.

For an input greater than 1999, all digits will be blanked except the overrange "1" indicator. The polarity indicator will remain lighted indicating the correct polarity. To remove an overload condition, change the Range Switch to a less sensitive position or decrease the input signal magnitude.

TABLE 2-4.

Input Volts	Digital Readout	Range Switch Designation
1.999×10^{-3}	1.999	mV
1.999×10^{-2}	19.99	mV
1.999×10^{-1}	199.9	mV
1.999	1.999	V
19.99	19.99	V
199.9	199.9	V
1000	1000	V

b. Ammeter Digital Display (Model 160 only).

1. When the Range Switch is placed in Amperes positions 100 nA through 1000 mA, the Multimeter digital display indicates the voltage across a calibrated, self-contained resistor. The Range Switch automatically selects the calibrated range resistor for current measurements from 1×10^{-7} to 1 ampere full scale.

2. The Range Switch is designated in convenient engineering units, nA (nanoamperes), μA (microamperes) and mA (milliamperes) with the decimal point automatically positioned in the display.

3. The full-scale current is determined by the Range Switch. Refer to Table 2-5 for the full-scale current ranges available on the Model 160.

TABLE 2-5.

Full Scale Range Amperes	Decimal Point Position	Range Switch Designation
1×10^{-7}	XX.X	nA
1×10^{-6}	.XXX	μA
1×10^{-5}	X.XX	μA
1×10^{-4}	XX.X	μA
1×10^{-3}	.XXX	mA
1×10^{-2}	X.XX	mA
1×10^{-1}	XX.X	mA
1	XXX	mA

4. The overranging feature of the instrument permits 100% overrange with a 1999 maximum display using all four digits. An input greater than 1999 will cause a blanking of the three righthand readouts the same as for voltage measurements.

c. Ohmmeter Display (Model 160 only).

1. When the Range Switch is placed in Ohms positions 100 Ω through 1000 MΩ, the Multimeter digital display designates the voltage across the unknown resistor with a fixed current applied.

2. The Range Switch is designated in convenient engineering units, Ω (ohms), KΩ (kilohms) and MΩ (megohms) with the decimal point automatically positioned in the readout.

3. The full-scale resistance is determined by the Range Switch. Refer to Table 2-6 for the full-scale resistance ranges available on the Model 160.

TABLE 2-6.

Full Scale Range Ohms	Decimal Point Position	Range Switch Designation
1×10^{2}	XX.X	Ω
1×10^{3}	.XXX	KΩ
1×10^{4}	X.XX	KΩ
1×10^{5}	XX.X	KΩ
1×10^{6}	.XXX	MΩ
1×10^{7}	X.XX	MΩ
1×10^{8}	XX.X	MΩ
1×10^{9}	XXX	MΩ

4. The overranging feature of the instrument permits 100% overrange with a 1999 maximum display using all four digits. An input greater than 1999 will cause a blanking of the three righthand readouts the same as for voltage measurements.

2-9. FLOATING OPERATION.

a. The low terminal can be floated above CASE ground by setting the rear panel LO Switch to FLOAT position. Isolation from circuit ground to chassis ground is greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.

b. When the instrument is used for off-ground voltage or current measurements, the low terminal is at floating potential. The instrument case ground should be connected to earth ground through the ground pin on the rear panel 3-prong AC POWER receptacle and line cord supplied.

2-10. ANALOG OUTPUT. The instrument has an analog output of ±1 volt at up to 1 milliampere for recording purposes. For off-ground operation, the analog ±1 volt OUTPUT should not be connected unless an external recorder is capable of floating at ±500 volts with greater than 100 megohms isolation such as the Keithley Model 370 recorder.

2-11. ZERO ADJUSTMENTS.

a. Short the input terminals with a low thermal connection - preferably a short copper wire or clip leads.

b. Set the front panel Range Switch to the 1 mV range.

c. If the digital display does not indicate zero, use the rear panel ZERO Control to adjust the instrument. Zero is indicated by flashing ± polarity lights.

d. Set the Range Switch to voltage positions 1 mV to 1000V while checking the readout so that zero is indicated on all ranges.

NOTE

If there is an off zero reading on the 1 volt range, it will be necessary to adjust the CURRENT OFFSET ADJ on the underside of the chassis. Refer to Figure 13.

e. Set the Range Switch to Ohms positions 1000 MΩ to 100 Ω while checking the readout so that zero is indicated on all ranges (Model 160 only).

NOTE

If clip leads are used on the input terminals, the lead resistance may be indicated on the 100 Ω range since the last digit sensitivity is 0.1 Ω per digit.

f. Set the Range Switch to Amperes positions 1000 mA to 100 nA while checking the readout so that zero is indicated on all ranges (Model 160 only).

g. Remove the short circuit at the input terminals.

1. Volts Ranges. The instrument will normally read off zero a small amount on the 1 mV through 100 mV ranges because of sensitivity to random noise. The readout should remain at zero on the ranges 1V through 1000V.

2. Ohms Ranges (Model 160 only). All Ohms ranges should indicate a readout overload where all digits except a "1" in the overrange position are blanked.

The + polarity indicator should also be lighted.

3. Amperes Ranges (Model 160 only). All current ranges should indicate a zero readout.

h. After the preceding checkout is made, the instrument should be useable for all measurements with no further adjustments necessary.

2-12. DIGITAL OUTPUTS AND EXTERNAL CONTROLS.

a. General.

1. The Model 1602 Digital Output Kit provides optional BCD outputs and controls.

2. Included is a 50-pin PRINTER/CONTROL Connector (receptacle) for mounting on the instrument rear panel.

3. An output buffer card plugs into a prewired connector on the chassis for either factory or user installation. Buffer card replaces PC-255 interconnecting card.

b. Output Codes and Levels.

1. The PRINTER/CONTROL Outputs are Binary Coded Decimal (BCD) Signals with 1-2-4-8 standard code.

2. The standard signal levels are as follows:

Output Logic "1" > +5 volts with less than 100 microamperes leakage.
Output Logic "0" < +0.5 volts with +50 milliamperes maximum allowable current.

3. The Buffer Stages utilize "Open Collector" output transistors. Therefore, the user must supply a pull-up resistor R and external voltage V_{EXT} for each buffered output as shown in Figure 5.

c. Output Information.

The Model 1602 Digital Output Kit provides various BCD outputs and controls as described in Tables 2-7 and 2-8.

TABLE 2-7.

Model 1602 Outputs

DIGITAL OUTPUT: BCD (1, 2, 4, 8) open collector logic (Motorola MC 858P) represents each of 3 digits, overrange digit, overload ("1"), polarity (+ = "1"), and decimal position (2 bits).

TIMING OUTPUTS:

Clock: Internal clock pulses (10 kHz count rate).

Count Interval: Logic "0" appears during count interval (i.e. pulse width is proportional to analog input signal).

Flag: Logic "1" appears for a 300 millisecond interval out of a conversion time of 500 milliseconds. No change in buffer storage is made outside this interval.

OUTPUT LOGIC LEVELS:

Output Logic "1": open transistor collector to ground with less than 100 microamperes leakage. +12 volts maximum allowable applied voltage.

Output Logic "0": transistor switch closure to ground with less than 0.5 volt saturation voltage. +50 milliamperes maximum allowable current.

REMOTE CONTROLS:

Strobe: Open circuit to ground inhibits all output lines from conducting (closure to ground enables conduction).

Hold: Closure to ground retains result of last conversion in both the output register and the display.

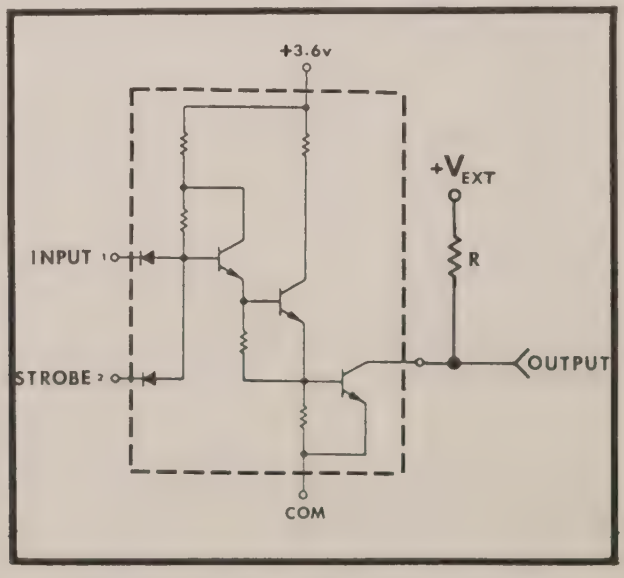


FIGURE 5. Model 1602 Output Buffer Stage.

TABLE 2-8.
Model 1602 PRINTER/CONTROL Connector Pin Identification

Pin No.	Output	Function	Pin No.	Output	Function
1	1×10^0	Data	26	Common	---
2	2×10^0	Data	27	Common	---
3	4×10^0	Data	28	Blank	---
4	8×10^0	Data	29	10 KHz	Clock
5	1×10^1	Data	30	Blank	---
6	2×10^1	Data	31	Blank	---
7	4×10^1	Data	32	Blank	---
8	8×10^1	Data	33	Blank	---
9	1×10^2	Data	34	Blank	---
10	2×10^2	Data	35	Blank	---
11	4×10^2	Data	36	Blank	---
12	8×10^2	Data	37	Blank	---
13	1×10^3	Data	38	Blank	---
14	+ = Logic "1"	Polarity	39	Blank	---
15	1×10^0	Decimal Point	40	Blank	---
16	2×10^0	Decimal Point	41	Blank	---
17	Blank	---	42	Blank	---
18	Logic "1"	Overload	43	Blank	---
19	Blank	---	44	Vcc2	External Voltage
20	Count Interval	See Table 2-7.	45	Blank	---
21	Blank	---	46	Blank	---
22	Blank	---	47	Hold	See Table 2-7.
23	Flag	See Table 2-7.	48	Blank	---
24	Common	---	49	Strobe	See Table 2-7.
25	Common	---	50	Blank	---

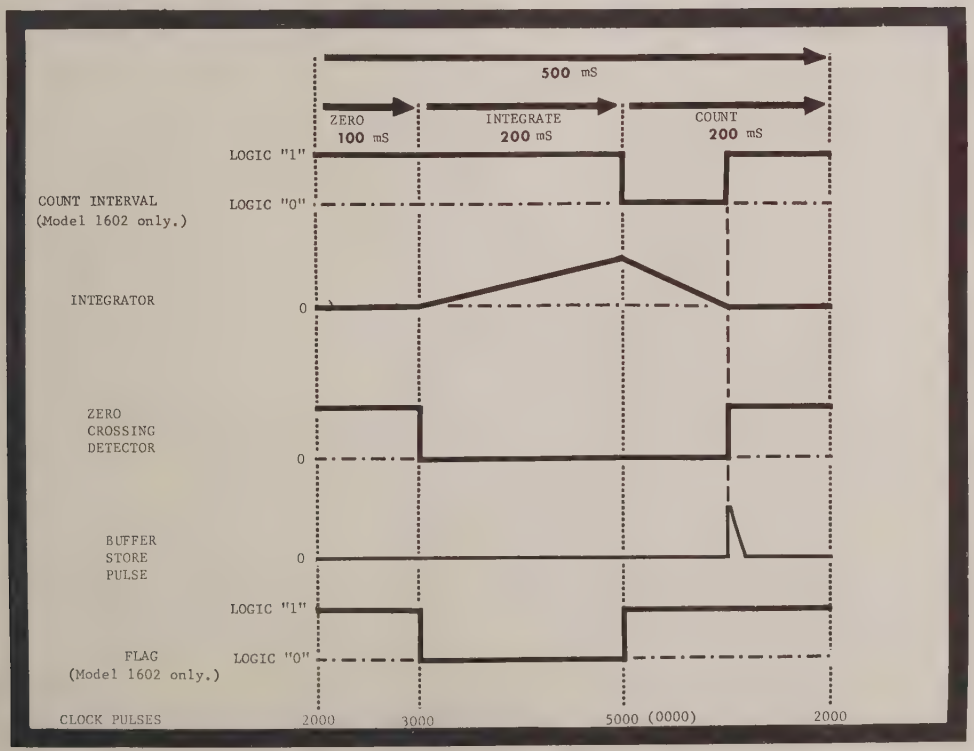


FIGURE 6. Timing Diagram.

2-13 CALIBRATION PROCEDURE.

a. General. This calibration procedure is useful for making calibration adjustments as necessary during in-coming inspection and preliminary checkout.

b. Preliminary Procedure.

1. Warm-up Period. With the Power Switch ON, allow the instrument to warm-up for a minimum of one half hour.

2. Power Supply Checkout. Measure the +15V d-c supply at the +15V test point on printed circuit board PC-254 as shown in Figure 6a. This voltage supply should be adjusted for +15.00 ± .050V using potentiometer R209 on PC-254 as shown in Figure 6a. The -15V and +3.6V power supplies cannot be adjusted since the +15V power supply is used as a reference voltage. Verify the remaining power supply voltages as follows:

-15V Nominal: Voltage limits should be within a range from -14.6V to -15.4V d-c.
+3.6V Nominal: Voltage limits should be within a range from +3.4V to +3.8V d-c.
+210V Nominal: Voltage limits should be within a range from +205V to +215V d-c. No adjustments can be made to the +210V power supply.

c. Calibration Adjustments.

1. Clock Frequency. Measure the clock frequency at the "CLOCK" test point on PC-254 as shown in Figure 6a. The frequency should be adjusted for a nominal 10 kilohertz ± 20 hertz using potentiometer R605 on PC-254 as shown in Figure 6a.

2. Zero and D-C Balance. Place a shorting wire across the Input terminals. Connect a voltmeter (with resolution to 0.1 millivolt) to the analog OUTPUT. Adjust the rear-panel ZERO Control (R505) for zero on the 1mV range. The OUTPUT should be adjusted within ± 0.1 millivolt d-c. Adjust the OFFSET CURRENT ADJ Control (R733) for zero on the 1V range. The OUTPUT should be adjusted within ± 0.1 millivolt. Repeat the adjustments of R505 and R733 until the OUTPUT is within ± 0.1 millivolt on both the 1mV and 1V ranges simultaneously.

NOTE

If the OUTPUT cannot be adjusted within ± 0.1 millivolt on the 1mV range, adjust the internal D-C Balance potentiometer (R722) located on printed circuit board PC-251.

3. Analog OUTPUT Calibration.

a) Voltage Ranges. Connect a voltmeter (with accuracy to ± 0.01%) to the analog Output. Connect an accurate voltage source across the Input terminals. Measure the analog OUTPUT voltage for each range as described in Table 2-9. Adjust the analog OUTPUT as necessary using the potentiometer or wire jumpers specified in Table 2-9.

b) Resistance Ranges (Model 160 only). Connect on accurate resistance decade box across the Input terminals. Measure the analog OUTPUT voltage for each range as described in Table 2-9. Adjust the OHMS CAL potentiometer (R738) for +1V ± 1.0 millivolt on the 1kΩ range only. No calibration adjustments can be made on the other ranges.

c) Current Ranges (Model 160 only). Connect an accurate current source across the Input terminals. Measure the analog OUTPUT voltage for each current range as indicated in Table 2-9. No calibration adjustments can be made on any of the current ranges.

d. A-D Converter Calibration. Connect a voltmeter (with accuracy to ± 0.01%) to the analog OUTPUT.

1. Zero Check. Connect a shorting wire across Input terminals. Adjust the rear-panel ZERO Control so that the Digital Display reading is 0-0-0-0 on the 1mV range with the Polarity Indicator alternating plus and minus. Measure the analog OUTPUT voltage which should be within ± 0.1 millivolt.

2. Full-Scale. Connect an accurate voltage source across the Input terminals and adjust for +1.9992V measured at the analog OUTPUT. Adjust the +CAL Control (R408) so that the Digital Display has a reading which alternates between 1-9-9-9 and a blanked display (with only the overrange "1" lighted). Apply a negative input and adjust the -CAL Control.

3. Linearity. Connect an accurate voltage source across the Input terminals and adjust for an analog OUTPUT of +0.9992V on the 1V range. Verify that the Digital Display reading is 0-9-9-9. Readjust the voltage source for an analog OUTPUT of +0.9998V on the 1V range. Verify a change of the Digital Display from 0-9-9-9 to 1-0-0-0.

TABLE 2-9.
Summary of Calibration Controls and Test Points.

Para. 2-13	Range Setting	Input Source	Source Accuracy	Analog OUTPUT Voltage	Analog OUTPUT Accuracy	Test Point	Control	Test Voltage	Tol.	Ref. Desig.	Loc.
b-2	---	---	---	---	---	+15V	15V ADJ	+15.00V	±.050V	R209	PC-254
	---	---	---	---	---	-15V	None	-15.0V	±0.4V	---	PC-254
	---	---	---	---	---	+3.6V	None	+3.6V	±0.2V	---	PC-254
	---	---	---	---	---	+210V	None	+210V	±5.0V	---	PC-254
c-1	---	---	---	---	---	CLOCK	CLOCK ADJ	10KHz	±20Hz	R605	PC-254
c-2	1mV	Short	---	0	±0.1mV	---	ZERO	---	---	R505	Rear
	1V	Short	---	0	±0.1mV	---	OFFSET ADJ	---	---	R733	Bottom
c-3a	100mV	100mV	±.01%	1.000V	±1mV	---	Jumper	---	---	R520,R521	PC-254
	10mV	10mV	±.01%	1.000V	±1mV	---	Jumper	---	---	R517,R518	PC-254
	1mV	1mV	±.01%	1.000V	±1mV	---	Jumper	---	---	R514,R515	PC-254
	1V	1V	±.01%	1.000V	±1mV	---	1V CAL	---	---	R111	PC-254
	10V	10V	±.01%	1.000V	±1mV	---	10V	---	---	R108	PC-254
	100V	100V	±.01%	1.000V	±1mV	---	100V	---	---	R106	PC-254
	1000V	1000V	±.01%	1.000V	±1mV	---	1000V	---	---	R104	PC-254
c-3b	1KΩ	1KΩ	±.01%	1.000V	±1mV	---	OHMS CAL	---	---	R738	Bottom
	100Ω	100Ω	±.02%	1.000V	±1mV	---	None				
	10KΩ	10KΩ	±.02%	1.000V	±4mV	---	None				
	100KΩ	100KΩ	±.02%	1.000V	±3mV	---	None				
	1MΩ	1MΩ	±.02%	1.000V	±3mV	---	None				
	10MΩ	10MΩ	±.4%	1.000V	±40mV	---	None				
	100MΩ	100MΩ	±1%	1.000V	±100mV	---	None				
	1000MΩ	1000MΩ	±3%	1.000V	±500mV	---	None				
c-3c	0.1μA	0.1μA	±.02%	1.000V	±2mV	---	None				
	1μA	1μA	±.02%	1.000V	±2mV	---	None				
	10μA	10μA	±.02%	1.000V	±2mV	---	None				
	100μA	100μA	±.02%	1.000V	±2mV	---	None				
	1mA	1mA	±.02%	1.000V	±2mV	---	None				
	10mA	10mA	±.02%	1.000V	±2mV	---	None				
	100mA	100mA	±.02%	1.000V	±3mV	---	None				
	1000mA	1000mA	±.02%	1.000V	±3mV	---	None				
	1000mA	100 mA	±.02%	1.000V	±0.3mV	---	None				
d-1	1mA	Short	---	0	±0.1mV	---	ZERO	---	---	R505	Rear
d-2	1V	Positive	---	+1.9992V	±0.1mV	---	+CAL	---	---	R408	PC-250
	1V	Negative	---	-1.9992V	±0.1mV	---	-CAL	---	---	R402	PC-250
d-3	1V	Positive	---	+0.9992V	±0.1mV	---	None				
	1V	Positive	---	+0.9998V	±0.1mV	---	None				

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL.

a. The basic digital voltmeter consists of two sections packaged together in one chassis: an analog amplifier and an analog-to-digital converter.

b. The analog amplifier is a variable-gain chopper amplifier.

c. The analog-to-digital converter is a dual-slope integrating type converter with two readings/second conversion rate. A BCD output and external control options are available when used with the Model 1602 Digital Output Kit.

3-2. ANALOG AMPLIFIER OPERATION. The analog amplifier is shown in the simplified block diagram, Figure 7.

a. Voltage Amplifier Operation. The amplifier has a full-scale sensitivity variable from 1 millivolt to 100 millivolts. Above 100 millivolts the input signal is divided down to the 100 mV full-scale level. The signal flow path can be described as follows: An input signal applied at the Input High terminal is attenuated by a resistor divider. The signal is filtered and applied to a modulator circuit. The a-c signal is then amplified and demodulated. A final variable gain d-c amplifier provides a d-c signal for the Analog output and A to D converter. The output is fedback to provide overall gain stability.

1. Input Resistor Divider. The input signal is attenuated by a divider network for RANGE Switch 1V, 10V, 100V and 1000V full-range positions.

2. Filter Network. The filter network provides a-c filtering for Normal Mode a-c noise.

3. Modulator Circuit. This circuit converts the low level d-c input to an a-c signal.

4. A-C Amplifier. This circuit uses negative feedback to provide gain accuracy and stability.

5. Demodulator Circuit. The demodulator is synchronized with the input modulator. It converts the amplified a-c signal to a d-c signal.

6. D-C Amplifier. This amplifier provides additional gain to drive the A to D converter and Analog recorder output.

7. Chopper Drive Circuit. This circuit generates the drive voltage for the mod-demod choppers.

NOTE

The circuit description for the ammeter and ohmmeter functions apply only for the Model 160 Digital Multimeter. Refer to Figure 8.

b. Ammeter Operation (Model 160 only). The instrument operates as an ammeter by detecting the voltage drop across a known shunt resistor. The sensitivity and resistor values are shown in Table 3-1.

c. Ohmmeter Operation (Model 160 only). The instrument provides a known constant current which is applied to the unknown resistance. The voltage output is proportional to the resistance measured.

3-3. ANALOG AMPLIFIER CIRCUITRY.

a. General. The circuits described in this section are located on the various sub-assemblies listed below and in Table 4-3 of Section 4.

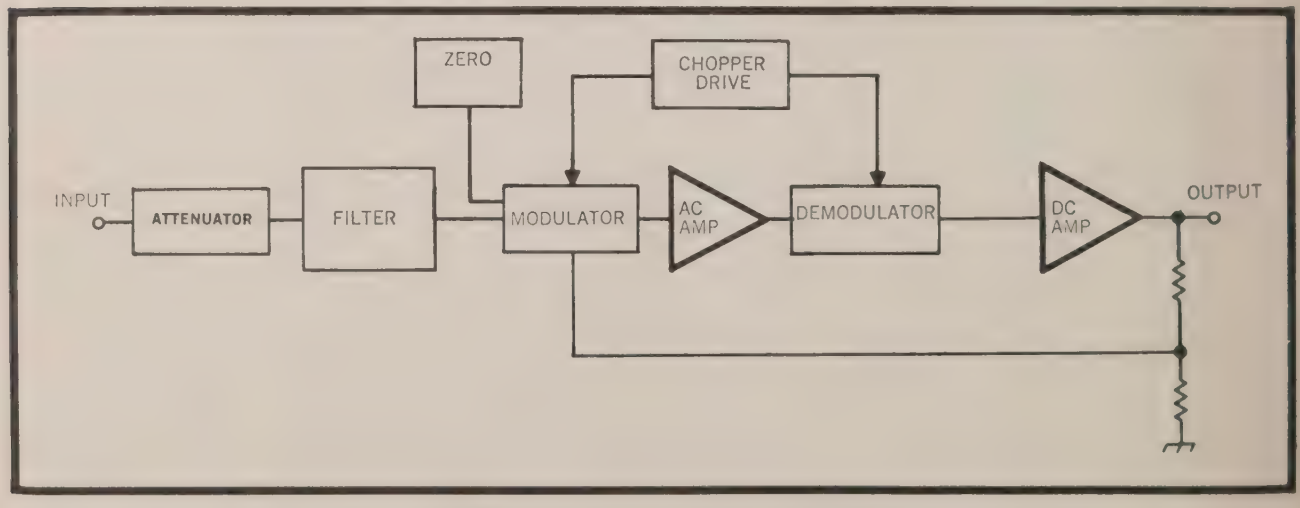


FIGURE 7. Analog Amplifier Block Diagram.

TABLE 3-1.

Full Scale Range Amperes	Shunt Resistor Ohms	Voltage Sensitivity
1×10^{-7}	10^5	10 mV
1×10^{-6}	10^4	10 mV
1×10^{-5}	10^3	10 mV
1×10^{-4}	10^2	10 mV
1×10^{-3}	10	10 mV
1×10^{-2}	1	10 mV
1×10^{-1}	.1	10 mV
1	.1	100 mV

1. Mother Board, PC-254.

2. Analog Amplifier, PC-251.

3. Connector Board, PC-255.

b. Voltage Amplifier Circuit. The voltage amplifier circuit is composed of a chopper amplifier with fractional feedback. The feedback resistors are selected by the Range Switch so as to maintain low feedback current. The feedback network, composed of resistors R513, R516, R519 and R703, is formed from the output of the d-c amplifier to the low side of the modulator.

1. Input Resistor Divider. The chopper amplifier has a minimum gain of 10 and a full-scale output voltage of ±1 volt. Thus it is necessary to attenuate signals greater than 100 millivolts to prevent saturation of the chopper amplifier. The input attenuator resistors R101, R102, and R103 through R111 are switched by the Range Switch S101.

2. Filter Network. The filter network provides NMRR as specified for line frequency voltages (either 50 or 60 Hz). The filter is a 2-section RC ladder filter composed of resistors R501 and R502 and capacitors C501 and C502.

3. Modulator Circuit. The modulator circuit utilizes MOS FET chopper switches to provide low offset voltage and current, low input noise, and low drive power. A series-shunt chopper configuration maintains high input impedance. Transistors Q701 and Q702 form the chopper.

4. A-C Amplifier. The a-c amplifier is a low noise amplifier composed of transistors Q703 and Q704 and an integrated circuit QA702.

5. Demodulator Circuit. The demodulator utilizes an FET shunt switch which is synchronized with the input modulator. The FET Q705 switching action creates a rectified d-c signal with a large chopper frequency a-c component. Resistors R717 and R718 with capacitor C710 provide a filtering action of the demodulated signal.

6. D-C Amplifier. The d-c amplifier utilizes an integrated circuit QA703 to provide d-c gain and capability of up to 1 milliampere at the analog output.

7. Chopper Drive Circuit. The chopper frequency signal is derived from the Oscillator circuit. Transistors Q706 and Q707 provide opposite phase square waves used to drive MOS-FET chopper transistors Q701 and Q702. Transistor Q708 provides a demodulator drive signal for FET Q705 which is synchronous with the modulator drive signals. Flip-Flop circuits QA701A and QA701B divide down the 909.09 Hz from the oscillator by 4:1 for a chopper drive of approximately 227.3 Hz.

8. Zero Adjustment Circuit. This circuit provides

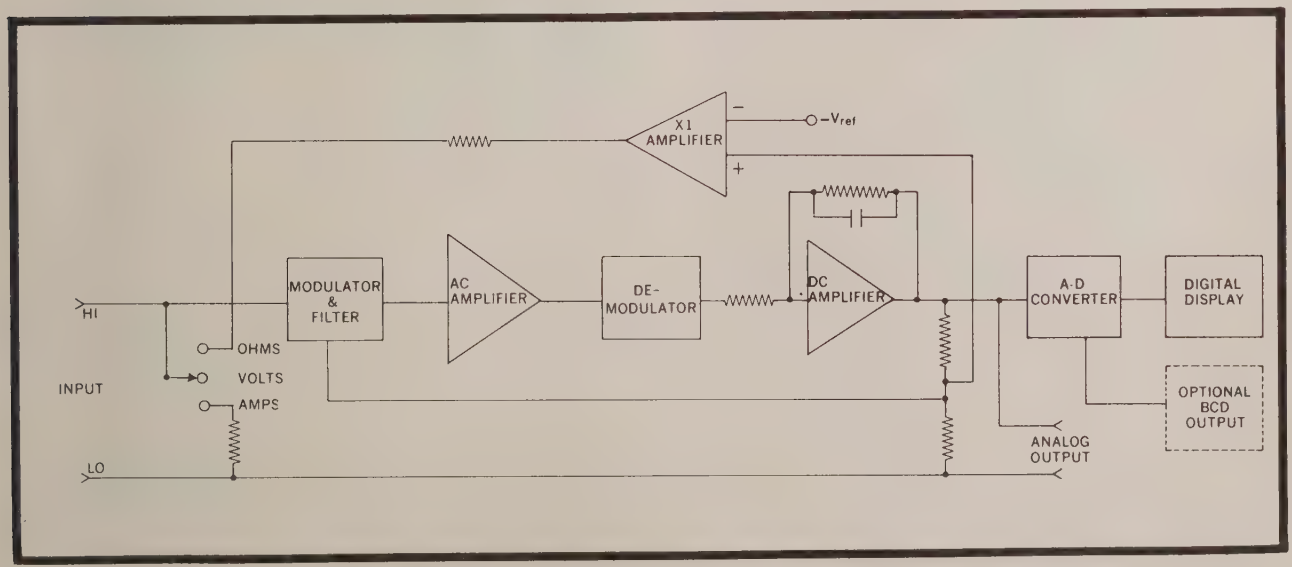


FIGURE 8. Multimeter Block Diagram.

limited adjustment of zero offset. It is composed of potentiometer R505 and resistors R503, R504, R506, R508 and R509.

c. Ammeter Circuit (Model 160 only). The instrument utilizes the chopper amplifier described above with various Range shunt resistors R116 through R122. The chopper amplifier functions as a voltage amplifier to provide an analog recorder output and drive for the A-to-D converter.

d. Ohmmeter Circuit (Model 160 only). The instrument provides a constant-current using a voltage reference amplifier and series resistor R. The reference voltage E limits the open-circuit voltage to 1.5 volts maximum. The voltage reference is composed of integrated circuit QA704 and reference diode D702.

3-4. ANALOG-TO-DIGITAL CONVERTER OPERATION.

a. General. (refer to Figure **9** for a detailed block diagram of the A-to-D converter) The analog-to-digital converter uses a dual slope integration technique which has inherent line frequency noise rejection. The analog signal is applied to the integrator for 200 milliseconds which is an even multiple of the line frequency of 50 or 60 Hz. The analog signal is then removed from the integrator input. The voltage on the integrator is then driven to zero to complete the voltage-to-time conversion. The time interval to reach a "Zero Crossing" is counted and displayed on the "Digital Readout" in proportion to the original analog signal. Before the sequence is repeated, the integrator is rezeroed. (Refer to the Timing Diagram shown in Figure 6.)

b. The A-to-D Converter is composed of eight major circuits.

1. Oscillator or Clock
2. BCD Counter
3. Program/Decoder
4. Integrator
5. Zero Crossing Detector
6. Buffer/Storage Register
7. Decoder/Driver
8. Numerical Readout.

c. Oscillator or Clock. The Oscillator produces pulses at a rate of 10 kilohertz for either 50 or 60 Hz operation.

d. BCD Counter. The BCD Counter counts the Clock pulses with a total range of 5000 counts. The Counter is composed of 4 individual counters designated 1, 10, 100, and 1000.

1. The "1", "10", and "100" counters have a capacity of ten counts each.

2. The "1000" counter has a capacity of five counts.

3. The total capacity of all four counters is 5000 counts.

e. Program/Decoder. The Program/Decoder circuit produces event commands to control the overall sequence of events for a complete A-to-D conversion.

TABLE 3-2.

Command	Function
2	ZERO
3,4	INTEGRATE
0,1	COUNT

f. Integrator. The Integrator circuit operation is composed of three periods (refer to Figure 6).

1. Zero Period. During this period the integrator amplifier is zeroed by a feedback rezeroing circuit as shown in Figure **10**. Switches S_a, S_b, and S_d are open to prevent integrator charging.

2. Integration Period. During this period switches S_b, S_c, and S_d are open. Switch S_a is closed to permit charging by the analog voltage for an even multiple of the line frequency.

3. Discharge Period. During this period, switch S_a is open to prevent further charging by the analog signal. Either switch S_c or S_d is closed to drive the Integrator voltage to zero. A reference current of opposite polarity to the input current is applied through either switch S_c or S_d. The Discharge Period ends when the Zero Crossing Detector circuit detects a zero Integrator output.

g. Zero Crossing Detector. The Zero Crossing Detector circuit provides a "High" or "Low" level output depending on the polarity of the detected input. Refer to Table 3-3 for a description of voltage outputs of the Zero Crossing Detector.

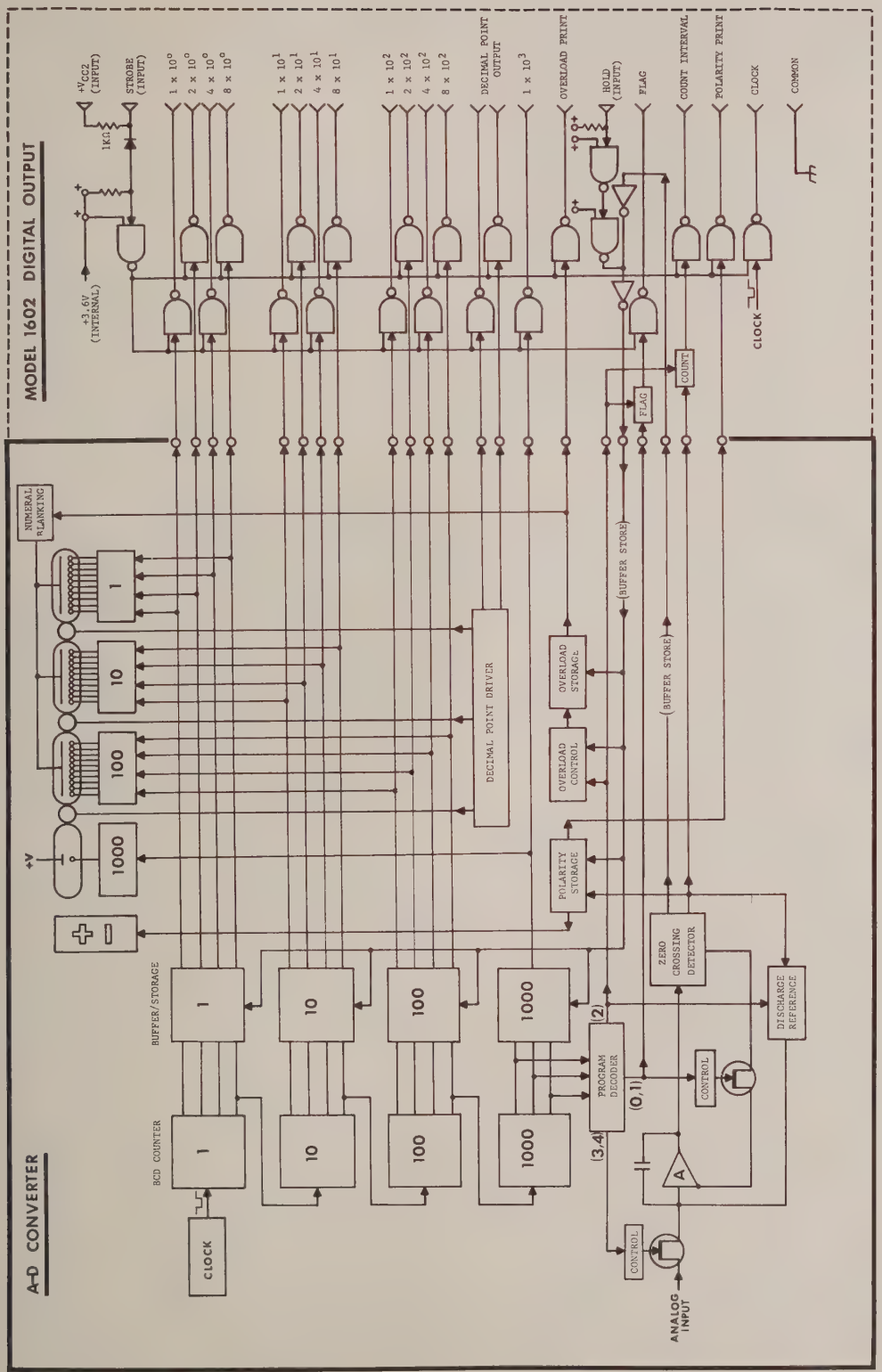
TABLE 3-3.
Zero Crossing Detector Output Levels.

M	N	B	C
0V	-0.5V	+1.5V	0V
0V	+3.5V	0V	+1.5V

h. Buffer/Storage Register. The Buffer/Storage Register is composed of "flip-flops" arranged to copy the states of the various BCD counters. The Buffer/Storage Register requires a Buffer Store command before any information can be transferred. The "flip-flop" circuits provide coded information for Decoder/Driver and the BCD outputs.

i. Decoder/Driver. The Decoder/Driver circuit decodes the BCD information from the Storage Register into ten-line decimal code. The Driver circuit then drives the proper numeral in each of the Numerical Readout tubes.

j. Numerical Readout. The Numerical Readout con-


MODEL 1602 DIGITAL OUTPUT
A-D CONVERTER
+VCC2 (INPUT)
STROBE (INPUT)
1KΩ
+3.6V (INTERNAL)
1 × 10^0
2 × 10^0
4 × 10^0
8 × 10^0
1 × 10^1
2 × 10^1
4 × 10^1
8 × 10^1
1 × 10^2
2 × 10^2
4 × 10^2
8 × 10^2
DECIMAL POINT OUTPUT
1 × 10^3
OVERLOAD PRINT
HOLD (INPUT)
FLAG
COUNT INTERVAL
POLARITY PRINT
CLOCK
COMMON
NUMERAL BLANKING
1
10
100
1000
+V
DECIMAL POINT DRIVER
OVERLOAD STORAGE
OVERLOAD CONTROL
POLARITY STORAGE
(BUFFER STORE)
(BUFFER STORE)
COUNT
FLAG
CLOCK
ZERO CROSSING DETECTOR
DISCHARGE REFERENCE
BUFFER/STORAGE
BCD COUNTER
1
10
100
1000
CLOCK
PROGRAM DECODER
(2)
(0,1)
(3,4)
CONTROL
CONTROL
A
ANALOG INPUT

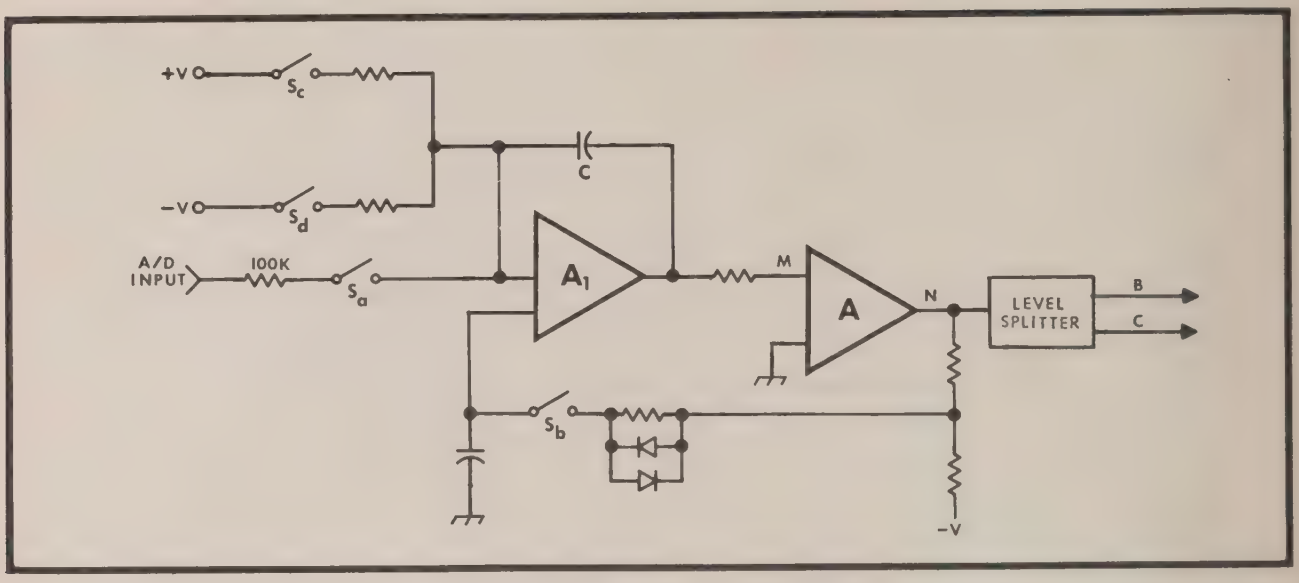


FIGURE 10. Integrator Block Diagram.

sists of four numerical indicators and one polarity indicator driven by the Decoder/Driver, Polarity and Overload Drivers.

k. Summary of Operation. The operation of the A-to-D Converter can be described by considering a typical conversion cycle.

1. The Clock provides pulses at a rate of 10 kilohertz.

2. The BCD Counter serves as a master timing control for the A-to-D conversion cycle. The timing is accomplished by the "1000" counter which has five coded states, namely 0, 1, 2, 3, and 4.

3. The Program/Decoder controls the sequence of commands based on the coded states from the BCD Counter. The decoded commands are described as shown in Table 3-2. The "2" command initiates the integrator ZERO period which removes any residual charge on the integrator capacitor. The "3,4" command initiates the INTEGRATE period which permits an integration of the analog signal. At the end of the INTEGRATE period, the "0,1" command initiates the COUNT period.

4. When the "3,4" command is given, the integrator is charged by the analog signal for a period of 200 milliseconds.

5. When the "0,1" command is given, the analog signal is removed and the integrator output is driven to zero by a reference current. The Zero Crossing Detector senses a zero crossing of the Integrator output and removes the reference current. The Detector provides outputs as shown in Table 3-3. The +1.5 volt levels are provided for control of the Integrator and Polarity Storage Register. A pulse command is also produced to initiate a Buffer/Store.

6. When the Buffer/Store command is given, the Buffer/Storage Register copies the BCD Counter states at that instant of time. The BCD coded information in the Register is then available for the Decoder/Driver and external printout.

7. The Decoder/Driver decodes the Buffer/Storage output and drives the Numerical Readout for a digital display.

8. The conversion cycle is completed when the BCD Counter reaches 2000 counts and the Program/Decoder provides a "2" command to initiate a new conversion cycle.

3-5. ANALOG-TO-DIGITAL CONVERTER CIRCUITRY.

a. General. The circuits described in this section are located on the various sub-assemblies listed below and in Table 4-3 of Section 4.

1. Tube Board, PC-248
2. Integrator Board, PC-250
3. Oscillator Circuit, PC-254.

b. Oscillator Circuit. The Oscillator circuit is located on a portion of printed circuit assembly PC-254. Refer to schematic diagram P/N 24691E for this circuit. Transistors Q601 and Q602, capacitors C601, C602, and C603 and resistors R606 and R607 form an oscillator. Potentiometer R605 is used to provide internal screwdriver adjustment of the oscillator frequency. Transistor Q603 serves as an emitter-follower to reduce output impedance. The chopper drive is obtained by dividing down the oscillator frequency from 10 Kilohertz to 909.09 Hz using integrated circuit QA801, a 11:1 Divider circuit.

c. Tube Board. The Tube board contains portions of five major circuits: the BCD Counter, the Program/Decoder, the Buffer/Storage Register, the Decoder Driver, and the Numerical Readout.

1. BCD Counter.

a) The Decade Counters designated "1", "10", and "100" are composed of individual integrated circuit modules QA308, QA309, and QA310 respectively.

b) The "1000" Counter is composed of integrated circuit modules QA301A, QA302A, and QA302B.

2. Program/Decoder. This circuit is composed of gates QA304A, QA304C, QA305 (B, C, D, E, F) QA306A and QA307B.

3. Buffer/Storage Register. This circuit is composed of integrated circuit modules QA311, QA312, and QA313.

4. Decoder Driver. This circuit is composed of integrated circuits QA314, QA315, and QA316.

5. Numerical Readout. V301, V302, V303 are Readout Tubes for Units, Tens, and Hundreds respectively.

6. Other circuits contained on the Tube Board are described as follows.

a) Overrange Indicator Circuit. This circuit is composed of integrated circuit module QA301B, transistor Q301 and overload indicator DS301.

b) Polarity Indicator Circuit. This circuit is composed of transistors Q305 and Q306 and Polarity indicator module DS302.

c) Display Rate/Hold Circuit. Gates QA303 (A, B, C, D) and QA304B, QA306B, and QA307A provide capability for Display Rate and Hold functions when used with additional Output Buffer circuits.

d. Integrator Board. The Integrator Board contains portions of three major circuits: the Integrator circuit, the Zero Crossing Detector Circuit, and the Feedback Rezeroing Circuit.

1. Integrator Circuit. (Refer to Figure **10** for identification of switches S_a, S_b, S_c, and S_d). The operation of the Integrator is controlled by the positions of switches S_a, S_b, S_c, and S_d. Switch S_a is Q401. Switch S_b is transistor Q411. Transistors Q404, Q405, Q408, Q409, and Q410 are control circuits arranged to control the proper FET switches depending on the signals at pins 12 and 13. The integrator amplifier consists of transistors Q402 and Q403 and integrated circuit QA401. The feedback capacitor is C406. Switches S_c and S_d control the current for 9-volt zener diodes D401 and D402. Resistors R403, R404, R405, R409, R410, and R411 are full-scale calibration resistors. Potentiometers R402 and R408 are internal screwdriver calibration adjustments.

2. Zero Crossing Detector Circuit. The high gain amplifier is composed of cascaded amplifiers QA402 and QA403. Diode D411 provides a 6-volt bias supply for QA403 and the output resistor network R444 and R445. The level-splitter circuit consists of diodes D414 and D415, resistors R443 and R446 and gates QA404 (A and B).

3. Feedback Rezeroing Circuit. This circuit provides rezeroing of the Integrator circuit using negative feedback from the Zero Crossing Detector output. Transistor Q411 is the equivalent of Switch S_b in Figure **10**. Resistor R434 and capacitor C414 form a feedback-loop filter circuit. Diodes D407 and D408 provide fast response for large input offsets due to input overloads.

3-6. POWER SUPPLIES.

a. ±15 Volt Supply.

1. The ±15 volt supplies tap a-c power from a secondary winding of transformer T201. Diodes D203 (A, B, C, and D) and capacitors C204, C205, C209, and C210 compose a full-wave rectifier with filtering.

2. The +15 volt regulator circuit utilizes integrated circuit QA201 which drives transistor Q206 to series regulate the output voltage. Potentiometer R209 provides calibration adjustment of the +15 volt supply. (Internal screwdriver adjustment).

3. Transistors Q211 and Q212 form a differential amplifier which compares the voltage at R218 with respect to low. The difference voltage is amplified by transistor Q210 and fed to Darlington transistor pair, Q207 and Q208, which series regulate the -15 volt output. Transistor Q209 limits the current output to approximately 200 milliamps.

b. +3.6 Volt Supply.

1. The +3.6 volt supply taps a-c power from a secondary of transformer T201. Diodes D201 and D202 and capacitor C201 form a full-wave rectifier with filtering.

2. Transistor Q205 amplifies the difference between the +3.6 output and a reference voltage derived from the +15 volt supply and determined by resistors R203 and R204. The difference voltage is amplified by transistor Q204 which drives a Darlington transistor pair, Q201 and Q202. The Darlington pair series regulates the +3.6 volt output.

3. Transistor Q203 limits the output current to about 3 amperes.

c. +210 Volt Output. The +210 volt supply is an unregulated voltage supply using the half-wave filtered voltage at diode D206 and capacitor C212.

d. +170 Volt Output.

1. Regulator. The +170 volts is derived from the +210 volts at emitter of Q302 which series regulates the +170V. Transistor Q303 provides a reference for the base of transistor Q302.

2. Blanking Circuit. This circuit controls the

+170 voltage for the three right hand readout tubes. The "Q" output of QA307B drives the base of transistor Q304 for normal regulator operation. When an overload occurs, the "Q" output is low turning off transistor Q304. This results in a drop of the +170 volt output causing blanking of the readout tubes.

SECTION 4. REPLACEABLE PARTS

4-1. REPLACEABLE PARTS LIST. This section contains a list of components used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufacturer Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of the Manufacturers is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 4-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
		Fig.	Figure		
CbVar	Carbon Variable			p	pico (10^{-12})
CerD	Ceramic Disc	GCb	Glass enclosed Carbon	PC	Printed Circuit
Cer Trimmer	Ceramic Trimmer			Poly	Polystyrene
Comp	Composition	k	kilo (10^{-3})		
				Ref.	Reference
DCb	Deposited Carbon	μ	micro (10^{-6})		
Desig.	Designation			TCu	Tinner Copperweld
		M	Meg (10^{6})		
EAL	Electrolytic, Aluminum	Mfg.	Manufacturer	V	volt
ETB	Electrolytic, tubular	MtF	Metal Film		
ETT	Electrolytic, tantalum	My	Mylar	W	watt
				WW	Wirewound
		No.	Number	WWVar	Wirewound Variable

4-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as described in Section 3. Refer to Table 4-2 which identifies all schematic part numbers included.

4-3. HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. The parts for the instrument's Main Chassis are listed followed by printed circuit boards and other sub-assemblies. Refer to Table 4-3 for listing of circuit designation series assigned to each major sub-assembly.

4-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

1. Instrument Part Number
2. Instrument Serial Number
3. Part Description
4. Schematic Circuit Designation
5. Keithley Part Number.

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 4-2.

Description	Circuit Designation	Schematic Part Number
Switching - Main Chassis	Front Panel	24687E
Power Supply	PC-254	24694D
Connectors	PC-254, PC-255	24692D
Analog Amplifier	PC-251	24691E
Integrator Board	PC-250	24690E
Tube Board	PC-248	24688D
Tube Board	PC-248	24689D

TABLE 4-3.

Circuit Desig.	Description	Connector Plug-In	Series	Page No.
-	Main Chassis	-	100	22
PC-254	Power Supply	-	200	23
PC-248	Tube Board	J802	300	24
PC-250	Integrator Board	J801	400	26
PC-254	Input Filter	-	500	28
PC-254	Oscillator	-	600	29
PC-251	Analog Amplifier	J902	700	30
PC-255	Connector Board	J901	800	32
PC-254	Connectors	-	900	32

TABLE 4-4.
Mechanical Parts List

Description	Quantity Per Assembly	Keithley Part No.	Fig. No.
(1) Chassis	1	(24010B (160) 24501B (163))	11, 12, 13
Cover Assembly			11
(2) Cover, sheet metal	1	24008C	
(3) Screws, #6 x 3/8" Phillips, Pan Head	4	-	
Feet Assembly			12
(4) Feet	4	24322B	
(5) Ball	4	FE-6	
(6) Screws, #8 x 3/8" Phillips, Pan Head	4	-	
Tilt Bail Assembly			12
(7) Bail	1	17147	
(8) Right Assembly	1	19206A	
(9) Left Assembly	1	19205B	
(10) Screws, #6 x 1/4" Phillips, Pan Head	2	-	
Cover Plate Assembly, Rear Panel			3
Cover Plate	1	24294A	
Screws, #6 x 1/4", Slotted	4	-	

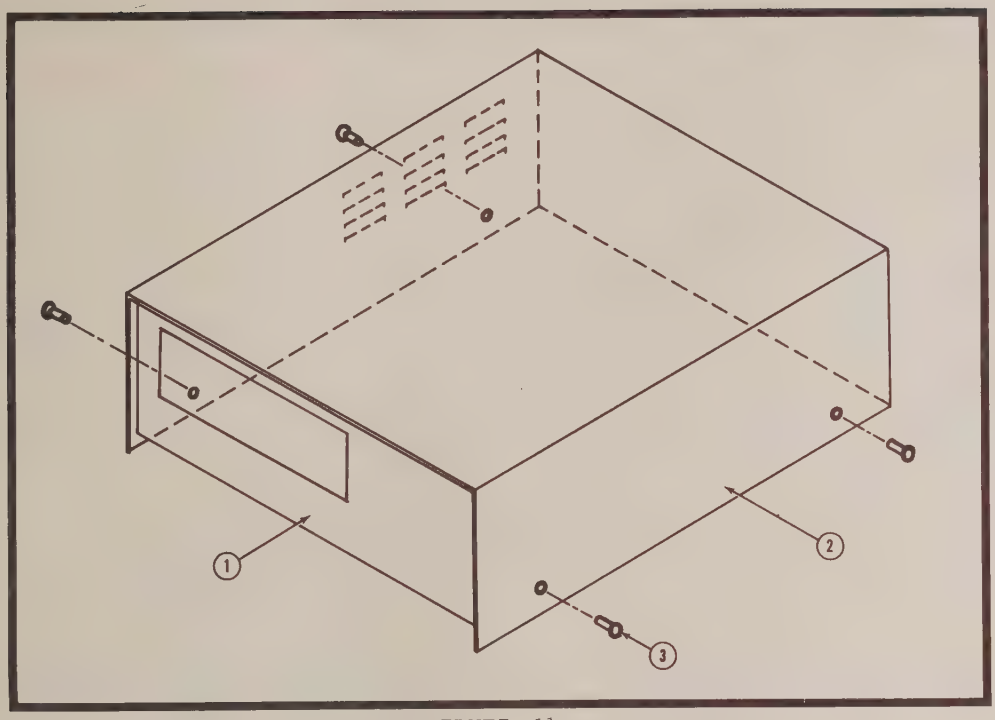


FIGURE 11.
Cover Assembly. Refer to Table 4-4.

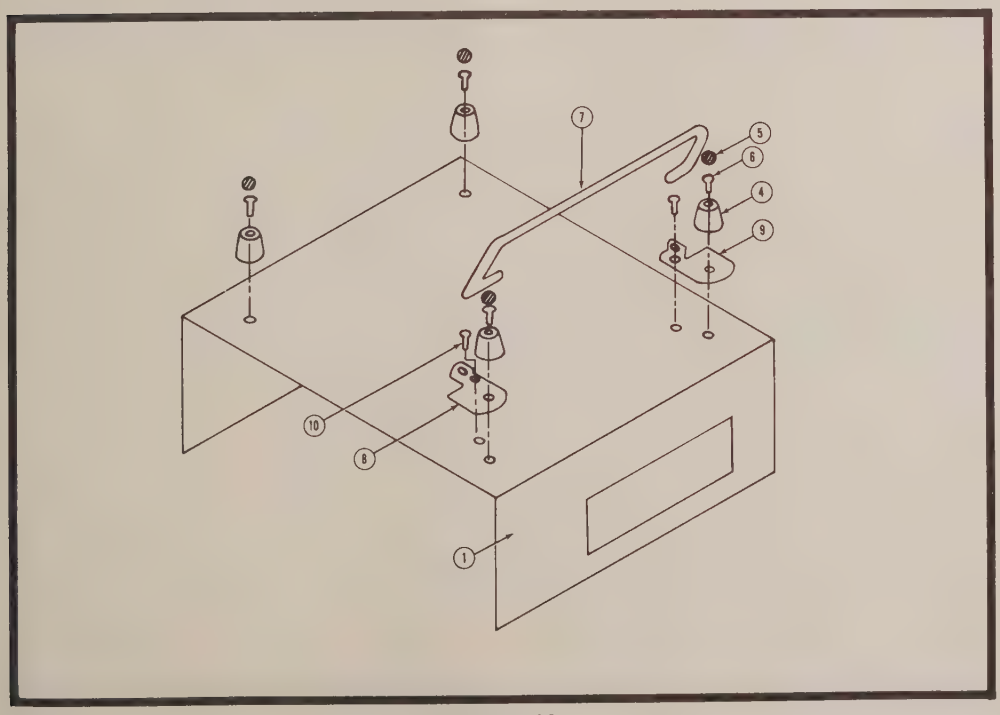


FIGURE 12.
Chassis Bottom View - Tilt Bail and Feet Assemblies. Refer to Table 4-4.

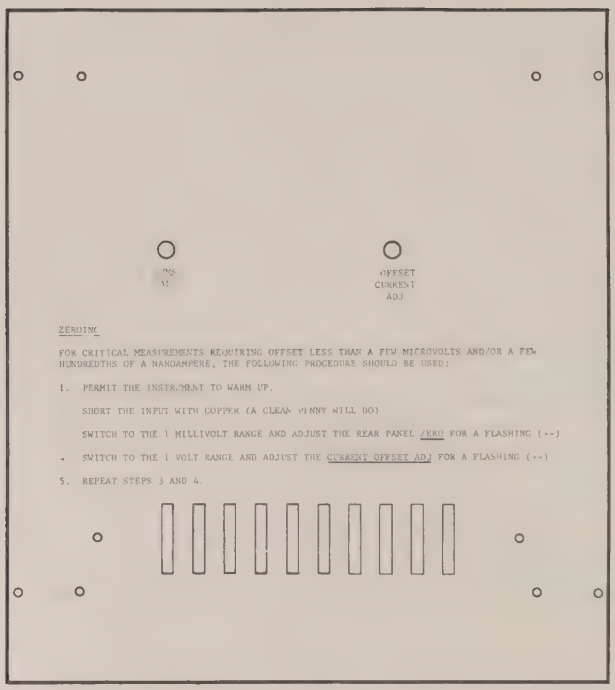

OFFSET
CURRENT
ADJ
ZEROING
FOR CRITICAL MEASUREMENTS REQUIRING OFFSET LESS THAN A FEW MICROVOLTS AND/OR A FEW HUNDREDTHS OF A NANOAMPERE, THE FOLLOWING PROCEDURE SHOULD BE USED:
1. PERMIT THE INSTRUMENT TO WARM UP.
SHORT THE INPUT WITH COPPER (A CLEAN PENNY WILL DO)
SWITCH TO THE 1 MILLIVOLT RANGE AND ADJUST THE REAR PANEL ZERO FOR A FLASHING (--)
SWITCH TO THE 1 VOLT RANGE AND ADJUST THE CURRENT OFFSET ADJ FOR A FLASHING (--)
5. REPEAT STEPS 3 AND 4.

FIGURE 13.
Chassis Bottom View - Calibration Adjustments.

TABLE 4-5.
Model 1005 Rack Mounting Kit Parts List.

Description	Quantity Per Assembly	Keithley Part No.	Figure No.
Dual Rack Mounting Assembly	---	24724C	15
A) Cover	1	24705D	
B) Side Plate	2	24707C	
C) Bottom Plate	1	24709B	
D) Screw, #6x1/4, Phillips, Pan Head	4	---	
E) Screw, #6x3/8, Phillips, Pan Head	4	---	
M) Shield Plate	1	24805B	
Single Rack Mounting Assembly	---	24724C	14
F) Side Plate, Single	1	24706C	
G) Brace	1	24708B	
H) Kep Nut, #8-32	2	---	
J) Screw, #8-32x3/8, Phillips, Flat Head	1	---	
K) Screw, #8-32x3/8, Button Head	1	---	

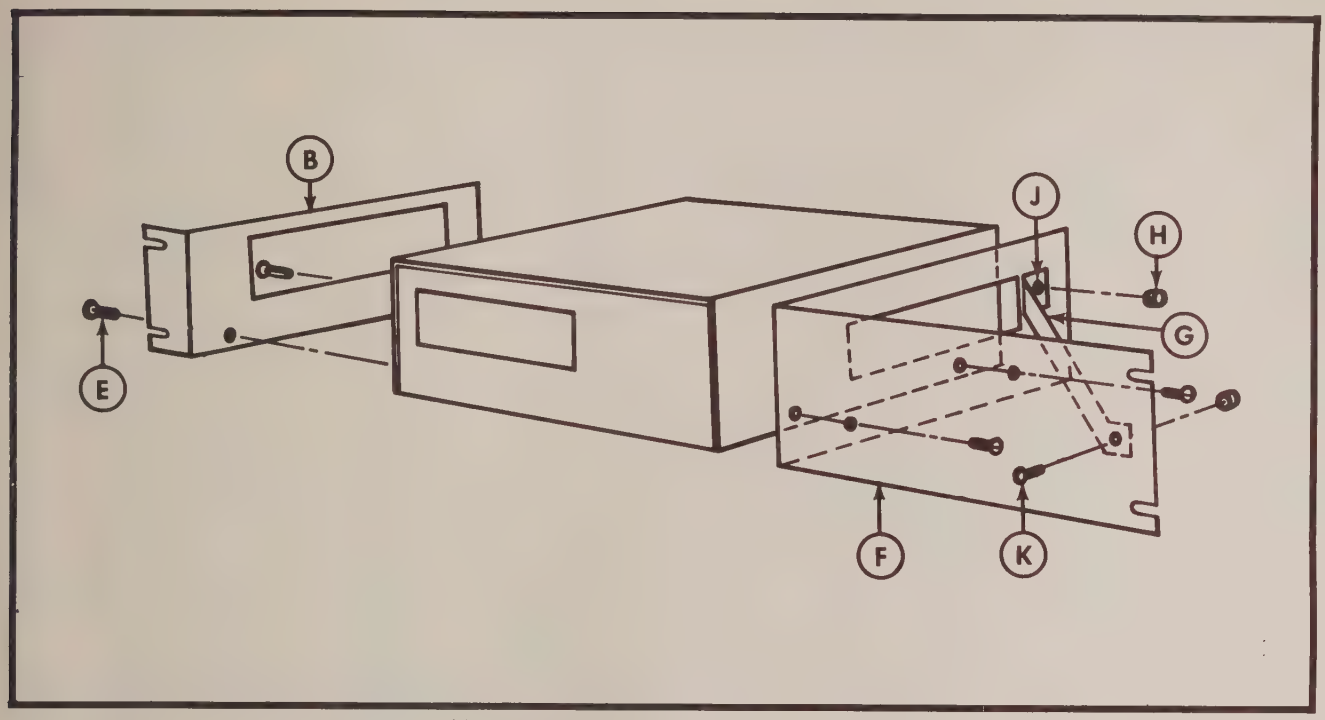


FIGURE 14. Model 1005 Rack Mounting Kit (Single).
(Refer to Table 4-5.)

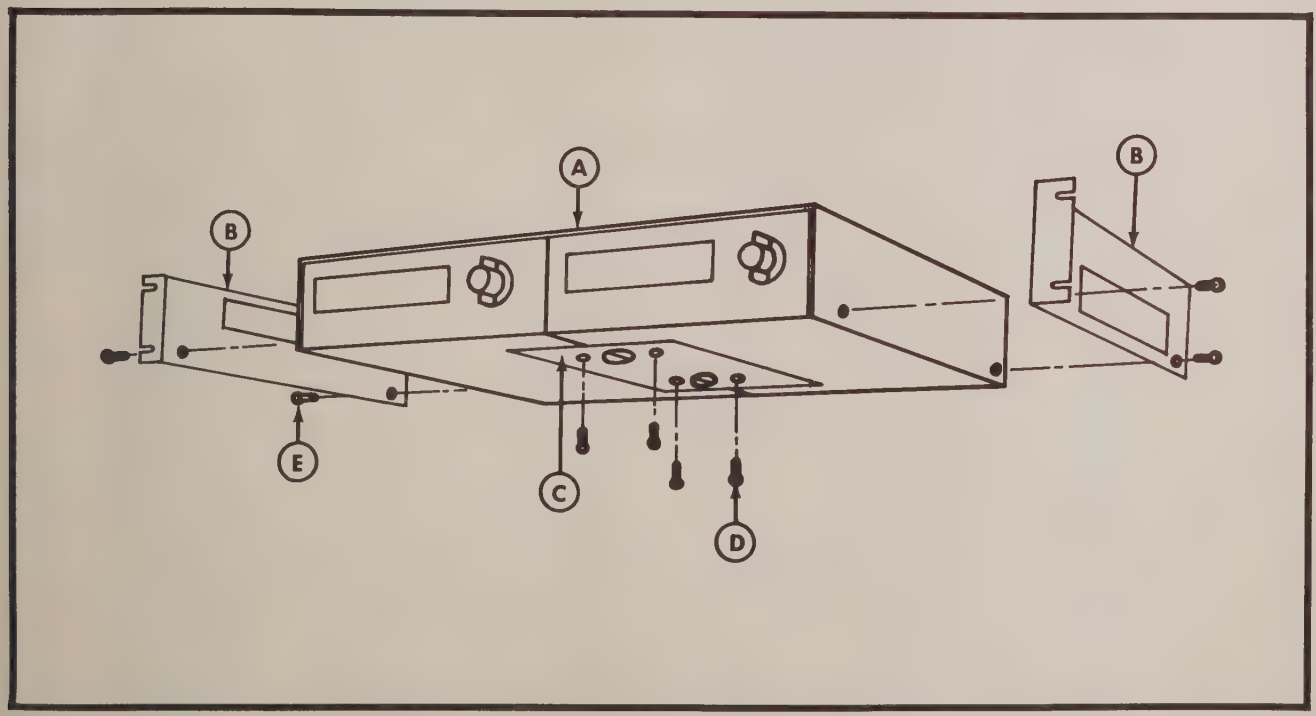


FIGURE 15. Model 1005 Rack Mounting Kit (Dual).
(Refer to Table 4-5.)

MAIN CHASSIS REPLACEABLE PARTS LIST
(Refer to Schematic Diagram 24687E for circuit designations)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C101	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C102	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C103	.0047 µF	600V	CerD	72982	ED	C22-.0047M	

MISCELLANEOUS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
J101	Binding Post, Input High , Red.	58474	DF21RC	BP-11R	
J102	Binding Post, Input Low , Black.	58474	DF21BC	BP-11B	
J104	Binding Post, Case Ground, Green.	58474	DF21GC	BP-11G	
J103	Receptacle, OUTPUT	02660	80PC2F	CS-32	
---	Connector, OUTPUT, mate of J103	02660	80MC2M	CS-33	
S101	Switch, Rotary Type, RANGE	80164	-	SW-319A	
S102	Switch, Slide Type	80164	-	SW-324	
--	Line Cord	70903	17258S	CO-6	

PRINTED CIRCUITS AND SUB-ASSEMBLIES

Circuit Desig.	Description	Module Part No.	Fig. Ref.
Power Supply (PC-254)	Mother Board	24263 (160) 24167 (163)	
PC-255	Connector Board	24265B	
PC-248	Tube Board	24199	
PC-250	Integrator Board	24223	
PC-251	Analog Board	24259 (160) 24166 (163)	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R101	10 MΩ	1%, 2 W	MtF	07716	MEH	R170-10M	
R102	200 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-200K	
R103	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	
R104	50 Ω	20%, 2 W	WW	71450	1NS-115	RP50-50	
R105	10 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-10K	
R106	500 Ω	20%, 2 W	WW	71450	1NS-115	RP50-500	
R107	100 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-100K	
R108	5 kΩ	20%, 2 W	WW	71450	1NS-115	RP50-5K	
R109	1 MΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1M	
R110	100 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-100K	
R111	50 kΩ	20%, 1.75 W	Cermet	73138	77PR	RP64-50K	
R112	10 MΩ	1%, 1 W	DCb	91637	DC-1	R13-10^7	
R113	10^9 Ω	20%, 1/2 W	Comp	75042	GBT	R37-10^9	
R114	10^8 Ω	1%, 2 W	DCb	91637	DC-2	R14-10^8	
R115	1 MΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1M	
R116	100 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-100K	
R117	10 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-10K	
R118	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	
R119	99.9Ω	0.1%, 1/2 W	MtF	91637	MFF	R169-99.9	
R120	0.1 Ω	0.1%, 5 W	WW	02985	TS-5W	R167-.1	

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R121	1 Ω	0.1%, 1/4 W	WW	01686	7009	R95-1	
R122	10 Ω	0.1%, 1/4 W	WW	01686	7009	R95-10	
R123	220 Ω	10%, 1/4 W	Comp	44655	RC07	R76-220	

POWER SUPPLY PARTS LIST
(Refer to Schematic Diagram 24694D for circuit designation).

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C201	2000 μF	15V	EAL	29309	367502000-15C	C93-2000M	
C202	220 pF	600V	CerD	72982	ED	C22-220P	
C203	150 pF	600V	CerD	72982	ED	C22-150P	
C204	200 μF	35V	EAL	90201	MTV200N35	C177-200M	
C205	200 μF	35V	EAL	90201	MTV200N35	C177-200M	
C206	10 μF	20V	ETT	17554	TSD1-20	C179-10M	
C207	470 pF	600V	CerD	72982	ED	C22-470P	
C208	125 μF	15V	ETB	73445	C426	C3-125M	
C209	200 μF	35V	EAL	90201	MTV200N35	C177-200M	
C210	200 μF	35V	EAL	90201	MTV200N35	C177-200M	
C211	125 μF	15V	ETB	73445	C426	C3-125M	
C212	15 μF	300V	EAL	90201	PTC015M300	C173-15M	

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D201	Silicon	13327	1N4139	RF-34	
D202	Silicon	13327	1N4139	RF-34	
D203	Four Diode Bridge	83701	PD-10	RF-36	
D204	Silicon	01295	1N645	RF-14	
D205	Silicon	01295	1N645	RF-14	
D206	Silicon	01295	1N3255	RF-17	

MISCELLANEOUS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
P201	Receptacle	82389	AC3G	CS-235	
F201	Fuse, 1/4 A, 250 V	71400	MDV	FU-33	
F202	Fuse, 1/2 A, 250 V	71400	MDV	FU-35	
S201	Switch, Toggle Type, Power On/Off	80164	-	SW-236	
S202	Switch, Slide Type, 117V-234V	79727	GG350PC	SW-318	
T201	Transformer	80164	TR-130	TR-130	
QA201	Integrated Circuit	07263	U5R772339	IC-14	

POWER SUPPLY (cont'd.)
RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R201	6.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-6.8K	
R202	0.2 Ω	10%	TCu	91637	CW-2	R151-0.2	
R203	10 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-10K	
R204	2.49 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-2.49K	
R205	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	
R206	3 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-3	
R207	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	
R208	3.32 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-3.32K	
R209	1 kΩ	20%, 2 W	WW	71450	1NS-115	RP50-1K	
R210	3.01 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-3.01K	
R211	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	
R212	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R213	10 Ω	10%, 1/2 W	Comp	01121	EB	R1-10	
R214	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R215	3 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-3	
R216	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R217	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R218	7.32 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.32K	
R219	82 Ω	10%, 1/2 W	Comp	01121	EB	R1-82	
R220	1 MΩ	10%, 1/4 W	Comp	44655	RC07	R76-1M	

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q201	Silicon, Power	02735	40312	TG-54	
Q202	Silicon	02735	2N5183	TG-68	
Q203	Silicon	07263	2N3565	TG-39	
Q204	Silicon	07263	2N3565	TG-39	
Q205	Silicon	07263	S17638	TG-33	
Q206	Silicon	02734	40317	TG-43	
Q207	Silicon	02734	40317	TG-33	
Q208	Silicon	02734	40319	TG-50	
Q209	Silicon	02734	40319	TG-33	
Q210	Silicon	02734	40319	TG-33	
Q211	Silicon	02734	40319	TG-33	
Q212	Silicon	02734	40319	TG-33	

TUBE BOARD (PC-248) PARTS LIST
(Refer to Schematic Diagrams 24688D and 24689D for circuit designations).

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C301	.0022 μF	600V	CerD	72982	ED	C22-.0022M	
C302	100 pF	600V	CerD	72982	ED	C22-100P	
C303	0.22 μF	10V	ETT	17554	TSD210226	C180-.22M	

INTEGRATED CIRCUITS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
QA301	Dual J-K Flip-Flops	04713	MC891P	IC-9	
QA302	Dual J-K Flip-Flops	04713	MC891P	IC-9	
QA303	Quad-2 Input Gate Positive Logic NOR	04713	MC824P	IC-5	

TUBE BOARD (cont'd.)
INTEGRATED CIRCUITS (Cont'd.)

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
QA304	Quad-2 Input Gate Positive Logic NOR	04713	MC724P	IC-5	
QA305	Hex Inverters	04713	M789P	IC-7	
QA306	Dual J-K Flip-Flops	04713	MC791P	IC-9	
QA307	Dual J-K Flip-Flops	04713	MC791P	IC-9	
QA308	Decade Counter	04713	MC880P	IC-17	
QA309	Decade Counter	04713	MC880P	IC-17	
QA310	Decade Counter	04713	MC880P	IC-17	
QA311	Quad Latch	04713	MC867P	IC-16	
QA312	Quad Latch	04713	MC867P	IC-16	
QA313	Quad Latch	04713	MC867P	IC-16	
QA314	Decimal Decoder/Driver	07263	U6B996079X	IC-3	
QA315	Decimal Decoder/Driver	07263	U6B996079X	IC-3	
QA316	Decimal Decoder/Driver	07263	U6B996079X	IC-3	

MISCELLANEOUS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
V301	Readout Tube, Units	80164	-	EV-841	
V302	Readout Tube, Tens	80164	-	EV-841	
V303	Readout Tube, Hundreds	80164	-	EV-841	
DS301	Readout Tube, Thousands	80164	-	PL-42	
DS302	Polarity Indicator	80164	-	PL-48	

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q301	Silicon	07263	2N5184	TG-67	
Q302	Silicon, Power	02735	40312	TG-44	
Q303	Silicon	02735	40346	TG-44	
Q304	Silicon	07263	2N5134	TG-65	
Q305	Silicon	07263	2N5184	TG-67	
Q306	Silicon	07263	2N5184	TG-67	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R301	100 kΩ	10%, 1 W	Comp	01121	GB	R2-100K	
R302	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R303	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	
R304	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R305	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R306	100 kΩ	10%, 1/2 W	Comp	01121	EB	R1-100K	
R307	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	
R308	Not Used						
R309	80.6 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-80.6K	
R310	7.87 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.87K	
R311	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	
R312	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R313	10 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-10K	
R314	10 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-10K	
R315	10 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-10K	

INTEGRATOR BOARD (PC-250) PARTS LIST
(Refer to Schematic Diagram 24690E for circuit designations)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C401	10 pF	600V	CerD	72982	ED	C22-10P	
C402	10 pF	600V	CerD	72982	ED	C22-10P	
C403	100 pF	600V	CerD	72982	ED	C22-100P	
C404	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C405	1.5 pF	600V	CerT	71590	TCZ-15	C77-1.5P	
C406	1 µF	100V	My	-	MF825	C185-1M	
C407	.001 µF	600V	CerD	72982	ED	C22-.001M	
C408	Not Used						
C409	220 pF	600V	CerD	72982	ED	C22-220P	
C410	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C411	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C412	22 µF	10V	ETT	17554	TSD2-10	C180-22M	
C413	5 pF	600V	CerD	72982	ED	C22-5P	
C414	1 µF	25V	CerD	56289	5C13	C85-1M	
C415	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C416	390 pF	600V	CerD	72982	ED	C22-390P	
C417	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C418	0.1 µF	250V	MtF	73445	C280AE	C178-.1M	
C419	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C420	10 µF	20V	ETT	17554	TSD1-20	C179-10M	

DIODES

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
D401	Zener	1N936	04713	DZ-5	
D402	Zener	1N936	04713	DZ-5	
D403	Silicon	2N3565	07263	TG-39	
D404	Silicon	2N3565	07263	TG-39	
D405	Silicon	1N914	01295	RF-28	
D406	Silicon	1N914	01295	RF-28	
D407	Silicon	1N914	01295	RF-28	
D408	Silicon	1N914	01295	RF-28	
D409	Silicon	1N914	01295	RF-28	
D410	Silicon	1N914	01295	RF-28	
D411	Zener		04713	DZ-38	
D412	Silicon	1N914	01295	RF-28	
D413	Silicon	1N914	01295	RF-28	
D414	Silicon	1N914	01295	RF-28	
D415	Silicon	1N914	01295	RF-28	
D416	Silicon	1N914	01295	RF-28	
D417	Silicon	1N914	01295	RF-28	

INTEGRATED CIRCUITS

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
QA401	Integrated Circuit	U5B770939X	07263	IC-1	
QA402	Integrated Circuit	U5B770939X	07263	IC-1	
QA403	High Speed Differential Comparator	U5B771039X	07263	IC-4	
QA404	Quad-2 Input Gate Positive Logic NOR	MC824P	04713	IC-5	

INTEGRATOR BOARD (cont'd).

TRANSISTORS

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q401	-	2N4220	04713	TG-42	
Q402	FET	T1S70	01295	TG-71	
Q403	FET	T1S70	01295	TG-71	
Q404	Silicon	2N5139	07263	TG-66	
Q405	Silicon	2N5134	07263	TG-65	
Q406	Not Used				
Q407	Not Used				
Q408	-	2N4220	04713	TG-42	
Q409	-	2N4220	04713	TG-42	
Q410	Silicon	2N5134	07263	TG-65	
Q411	-	2N4220	04713	TG-42	
Q412	Silicon	2N5134	07263	TG-65	
Q413	Silicon	2N5139	07263	TG-66	
Q414	Silicon	2N5134	07263	TG-65	
Q415	Silicon	2N5139	07263	TG-66	
Q416	Silicon	2N5134	07263	TG-65	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R401	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	
R402	10 kΩ	20%, 1.75 W	Cermet	73138	77PR-10K	RP64-10K	
R403	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R404	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R405	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R406	*442 Ω	1%, 1/8 W	MtF	91637	MFF-1/8	R177-442	
R407	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	
R408	10 kΩ	20%, 1.75 W	Cermet	73138	77PR-10K	RP64-10K	
R409	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R410	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R411	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	
R412	*442 Ω	1%, 1/8 W	MtF	91637	MFF-1/8	R177-442	
R413	49.9 kΩ	1%, 1/8 W	MtF	91637	MFF-1/8	R177-49.9K	
R414	49.9 kΩ	1%, 1/8 W	MtF	91637	MFF-1/8	R177-49.9K	
R415	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R416	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R417	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	
R418	301 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-301K	
R419	301 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-301K	
R420	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R421	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	
R422	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33 K	
R423	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	
R424	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	
R425	Not Used					-	
R426	Not Used					-	
R427	Not Used					-	
R428	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	
R429	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	
R430	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R431	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.7K	
R432	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R433	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R434	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R435	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	

* Nominal

INTEGRATOR BOARD (cont'd.)
RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R436	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R437	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	
R438	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R439	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R440	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R441	8.87 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-8.87K	
R442	3.01 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-3.01K	
R443	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	
R444	2.49 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-2.49K	
R445	10 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-10K	
R446	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	
R447	237 Ω	1%, 1/8 W	MtF	00716	CEA	R88-237	
R448	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	
R449	1 kΩ	1%, 1/8 W	MtF	00716	CEA	R88-1K	
R450	4.99 kΩ	1%, 1/8 W	MtF	00716	CEA	R88-4.99K	
R451	27 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-27K	
R452	82 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-82K	
R453	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R454	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	
R455	237 Ω	1%, 1/8 W	MtF	00716	CEA	R88-237	
R456	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	
R457	4.99 kΩ	1%, 1/8 W	MtF	00716	CEA	R88-4.99K	
R458	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	

INPUT FILTER (PC-254) PARTS LIST
(Refer to Schematic Diagram 24691E for circuit designations)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C501	0.1 μF	200V	My	13050	SM2A	C143-.1M	
C502	0.1 μF	200V	My	13050	SM2A	C143-.1M	
C503	2 μF	100V	My	-	MF1195	C188-2M	

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D501	Silicon	01295	1N645	RF-14	
D502	Silicon	01295	1N645	RF-14	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R501	150 kΩ	10%, 1/2 W	Comp	01121	EB	R1-150K	
R502	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	
R503	1 MΩ	1%, 1/8 W	MtF	07716	CEA	R88-1M	
R504	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	
R505	100 kΩ	20%, 1.75 W	Cermet	73138	77PR-100K	RP64-100K	
R506	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	
R507	Not Used						
R508	1.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1.5K	
R509	1.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1.5K	
R510	10 MΩ	10%, 1/4 W	Comp	44655	RC07	R76-10M	

INTEGRATOR BOARD (Cont'd.)
RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R511	100 MΩ	20%, 1/2 W	Comp	75042	GBT	R37-10^8	
R512	1000 MΩ	20%, 1/2 W	Comp	75042	GBT	R37-10^9	
R513	89.9 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-89.9K	
R514	100 Ω	1%, 1/8 W	MtF	07716	CEA	R88-100	
R515	100 Ω	1%, 1/8 W	MtF	07716	CEA	R88-100	
R516	8.99 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-8.99K	
R517	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	
R518	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	
R519	899 Ω	0.1%, 1/2 W	MtF	91637	MFF	R169-899	
R520	1 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-1	
R521	1 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-1	

OSCILLATOR (PC-254) PARTS LIST
(Refer to Schematic Diagram 24691E for circuit designations).

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig Ref.
C601	.047 μF	200V	My	13050	SM2A	C143-.047M	
C602	500 pF	50V	Poly	00686	A10R	C189-500P	
C603	500 pF	50V	Poly	00686	A10R	C189-500P	
C604	1500 pF	50V	Poly	00686	A10R	C189-1500P	
C605	10 μF	20V	ETT	17554	TSD1-20	C179-10M	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mtr. Desig.	Keithley Part No.	Fig. Ref.
R601	3.01 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-3.01K	
R602	113 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-113K	
R603	100 Ω	1%, 1/8 W	MtF	07716	CEA	R88-100	
R604	6.98 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-6.98K	
R605	5 kΩ	20%, 2 W	WW	71450	1NS-115	RP50-5K	
R606	32.4 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-32.4K	
R607	32.4 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-32.4K	
R608	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R609	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	
R610	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R611	10 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-10K	

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q601	Silicon	04713	2N5089	TG-62	
Q602	Silicon	04713	2N5089	TG-62	
Q603	Silicon	04713	2N5089	TG-62	

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D601	Silicon	01295	1N914	RF-28	

ANALOG AMPLIFIER (PC-251) PARTS LIST
(Refer to Schematic Diagram 24691E for circuit designations).

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C701	Not Used						
C702	.01 µF	200V	My	13050	SM1A	C47-.01M	
C703	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C704	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C705	1.2 µF	20V	ETT	17554	TSD1-20	C179-1.2M	
C706	1.2 µF	20V	ETT	17554	TSD1-20	C179-1.2M	
C707	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C708	220 pF	600V	CerD	72982	ED	C22-220P	
C709	0.1 µF	250V	MtF	73445	C280AE	C178-.1M	
C710	0.22 µF	250V	MtF	73445	C280AE	C178-.22M	
C711	0.1 µF	250V	MtF	73445	C280AE	C178-.1M	
C712	33 pF	600V	CerD	72982	ED	C22-33P	
C713	10 µF	20V	ETT	17554	TSD1-20	C179-10M	
C714	150 pF	500V	Poly	71590	CPR	C138-150P	
C715	.001 µF	500V	Poly	71590	CPR	C138-.001M	
C716	500 pF	160V	Poly	24972	KS50025160	C196-500P	
C717	500 pF	160V	Poly	24972	KS50025160	C196-500P	
C718	.0047 µF	600V	CerD	72982	ED	C22-.0047M	
C719	220 pF	600V	CerD	72982	ED	C22-220P	
C720	10 µF	20V	ETT	17554	TSD1-20	C179-10M	

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D701	Silicon	01295	1N645	RF-14	
D702	Zener	04713	1N936	DZ-5	

INTEGRATED CIRCUITS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
QA701	Dual J-K Flip-Flops	04713	MC890P	IC-8	
QA702	Integrated Circuit	07263	U5B770939X	IC-1	
QA703	Integrated Circuit	12040	LM-301AH	IC-2	
QA704	Integrated Circuit	12040	LM-301AH	IC-2	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R701	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	
R702	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	
R703	100 Ω	.05%, 1/4 W	WW	17870	1352	R157-100	
R704	1 MΩ	10%, 1/4 W	Comp	44655	RC07	R76-1M	
R705	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	
R706	100 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-100K	
R707	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	
R708	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R709	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	
R710	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	
R711	1 MΩ	10%, 1/4 W	Comp	44655	RC07	R76-1M	
R712	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	

ANALOG AMPLIFIER (Cont'd.)
RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R713	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R714	470 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-470K	
R715	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	
R716	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R717	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	
R718	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	
R719	68 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-68K	
R720	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	
R721	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	
R722	500 Ω	1/4 W	Carbon	76055	MTC52L1	RP59-500	
R723	68 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-68K	
R724	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R725	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R726	470 Ω	10%, 1/4 W	Comp	44655	RC07	R76-470	
R727	4.75 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.75K	
R728	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	
R729	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R730	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1K	
R731	4.75 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.75K	
R732	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	
R733	50 kΩ	20%, 1.75 W	Cermet	73138	77 PR	RP64-50K	
R734	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	
R735	100 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-100K	
R736	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	
R737	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1K	
R738	2 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-202	RP39-2K	
R739	8.06 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-8.06K	
R740	9.9 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-9.9K	
R741	100 Ω	0.1%, 1/8 W	MtF	91637	MFF	R168-100	
R742	100 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-10K	
R743	10 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-10K	
R744	Not Used						
R745	10 kΩ	0.1%, 1/8 W	MtF	91637	MFF	R168-10K	
R746	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	
R747	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	
R748	470 Ω	10%, 1/4 W	Comp	44655	RC07	R76-470	

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q701	-	94145	RN1030	TG-51	
Q702	-	94145	RN1030	TG-51	
Q703	Silicon	04713	2N5089	TG-62 (24219A)	
Q704	Silicon	04713	2N5087	TG-61	
Q705	-	04713	MPF-103	TG-41	
Q706	Silicon	04713	2N5089	TG-62	
Q707	Silicon	04713	2N5089	TG-62	
Q708	Silicon	04713	2N5087	TG-61	

CONNECTOR BOARD (PC-255) PARTS LIST
(Refer to Schematic Diagram 24692D for circuit designations).

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
J801	Receptacle, 22-Pin	PSC4SS2212	09922	CS-182	
J802	Receptacle, 44-Pin	PSC4DD2212	09922	CS-205	
QA801	Integrated Circuit	MC877P	04713	IC-21	
R801	Resistor, 10 kΩ, 10%, 1/4 W, Comp	RC07	44655	R76-10K	
C801	Capacitor, .001 μF, 600V, CerD	ED	72982	C22-.001M	

MOTHER BOARD (PC-254) PARTS LIST
(Refer to Schematic Diagram 24692D for circuit designations).

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
J901	Receptacle, 22-Pin	PSC4SS2212	09922	CS-182	
J902	Receptacle, 22-Pin	PSC4SS2212	09922	CS-182	
J903	Receptacle, 10-Pin	20052	22526	CS-237	
J904	Receptacle, 10-Pin	20052	22526	CS-237	
J905	Receptacle, 10-Pin	20052	22526	CS-237	
J906	Receptacle, 10-Pin	20052	22526	CS-237	

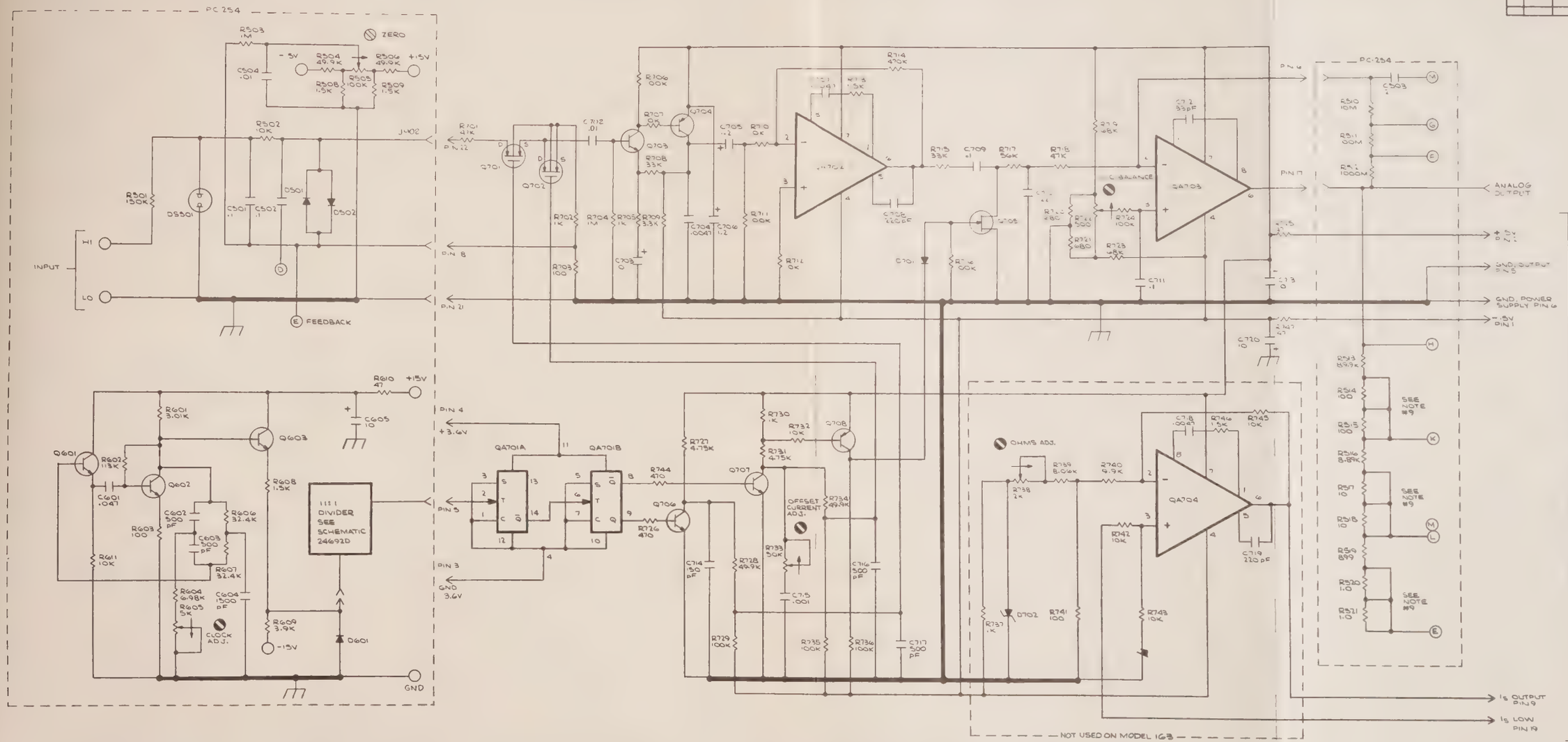
CODE TO NAME List of Suggested Manufacturers.
Reference: Federal Supply Code for Manufacturers, Cataloging Handbook H4-2.

00656	Aerovox Corp. 740 Belleville Ave. New Bedford, Mass. 02741
00686	Film Capacitors, Inc. 100 Eighth St. Passaic, N.J.
01121	Allen-Bradley Corp. 1201 South 2nd St. Milwaukee, Wisc. 53204
01295	Texas Instruments, Inc. Semiconductor-Components Div. Dallas, Texas 75231
01686	RCL Electronics, Inc. 195 McGregor St. Manchester, N.H. 03102
02101	Varo Inc. Electrokinetics Div. Santa Barbara, Calif. 93102
02660	Amphenol Corp. 2801 South 25th Ave. Broadview, Ill. 60153
02734	Radio Corp. of America Defense Electronic Products Camden, N.J.
02735	Radio Corp. of America Receiving Tube Div. Somerville, N.J.
02777	Hopkins Engineering Co. 12900 Foothill Blvd. San Fernando, Calif. 91342
02985	Tepro Electric Corp. 5 St. Paul St. Rochester, N.Y. 14604
03508	General Electric Co. Semiconductor Products Dept. Syracuse, N.Y. 13201
04009	Arrow-Hart & Hegeman Electric Co. 103 Hawthorne St. Hartford, Conn. 06106
04713	Motorola Semiconductor Prod. Inc. 5005 E. McDowell Rd. Phoenix, Ariz. 85008
05079	Tansistor Electronics, Inc. 1000 West Road Bennington, Vt. 05201
05397	Union Carbide Corp. Electronics Div. New York, N.Y. 10017
06751	Components, Inc. Arizona Div. Phoenix, Ariz. 85019
06980	Varian Assoc. EIMAC Div. 301 Industrial Way San Carlos, Calif. 94070
07137	Transistor Electronics Corp. Hwy. 169 - Co. Rd. 18 Minneapolis, Minn. 55424
07263	Fairchild Camera & Inst. Corp. 313 Frontage Road Mountain View, Calif.
07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601
08811	GL Electronics Div. of GL Industries, Inc. Westville, N.J. 08093
09052	Gulton Industries, Inc. Alkaline Battery Div. Metuchen, N.J.
09823	Burgess Battery Co. Div. of Servel Inc. Freeport, Ill.
09922	Burndy Corp. Richards Ave. Norwalk, Conn. 06852
10582	CTS of Asheville Inc. Mills Gap Road Skyland, N.C.
11502	IRC Inc. Greenway Road Boone, N.C. 28607
11837	Electro Scientific Indus., Inc. 13645 NW Science Park Dr. Portland, Or. 97229
12040	National Semiconductor Corp. Commerce Drive Danbury, Conn. 06813
12065	Transitron Electronic Corp. 144 Addison St. East Boston, Mass.
12697	Clarostat Mfg. Co., Inc. Lower Washington St. Dover, N.H. 03820
12954	Dickson Electronics Corp. 302 S. Wells Fargo Ave. Scottsdale, Ariz.
13050	Potter Co. Highway 51 N. Wesson, Miss. 39191
13327	Solitron Devices, Inc. 256 Oak Tree Road Tappan, N.Y. 10983
13934	Midwec Corp. 602 Main Oshkosh, Nebr. 69154
14655	Cornell-Dubilier Electric Corp. 50 Paris Street Newark, N.J.
14659	Sprague Electric Co. P.O. Box 1509 Visalia, Calif. 93278
15238	ITT Semiconductors Div. of ITT Corp. Lawrence, Mass. 01841
15909	Daven Div. of T.A. Edison Ind. McGraw Edison Co. Livingston, N.J.
16170	Teledyne Systems Co. Communications Div. Los Angeles, Calif. 90066
17554	Components, Inc. Smith St. Biddeford, Ma. 04005
23020	General Reed Co. 174 Main St. Metuchen, N.J. 08840
24655	General Radio Co. 22 Baker Ave. West Concord, Mass. 01781
27682	Hathaway Instruments, Inc. 5800 E. Jewell Ave. Denver, Colorado 80222
28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, N.J.
29309	Richey Electronics Inc. 1307 Dickerson Rd. Nashville, Tenn. 37213
35529	Leeds and Northrup 4901 Stenton Ave. Philadelphia, Pa. 19144
37942	Mallory, P. R. and Co., Inc. 3029 E. Washington St. Indianapolis, Ind. 46206
44655	Ohmite Mfg. Co. 3601 Howard St. Skokie, Ill. 60076
53201	Sangamo Electric Co. 1301 North 11th Springfield, Ill. 62705
54294	Shallcross Mfg. Co. 24 Preston St. Selma, N.C.
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co., The 383 Middle St. Bristol, Conn. 06012
61637	Union Carbide Corp. 270 Park Ave. New York, N.Y. 10017

CODE TO NAME List (Continued).

63060	Victoreen Instrument Co. 5806 Hough Ave. Cleveland, Ohio 44103
70309	Allied Control Co., Inc. 2 East End Ave. New York, N.Y.
70903	Belden Mfg. Co. 415 So. Kilpatrick Chicago, Ill. 60644
71002	Birnbach Radio Co., Inc. 147 Hudson St. New York, N.Y.
71279	Cambridge Thermionic Corp. 430 Concord Avenue Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
71450	CTS Corp. 1142 W. Beardsley Ave. Elkhart, Ind.
71468	ITT Cannon Electric, Inc. 3208 Humbolt St. Los Angeles, Calif. 90031
71590	Centralab Div. of Globe-Union, Inc. Milwaukee, Wisc. 53212
71785	Cinch Mfg. Co. and Howard B. Jones Div. Chicago, Ill. 60624
72619	Dialight Corp. 60 Stewart Ave. Brooklyn, N.Y. 11237
72653	G-C Electronics Co. 400 S. Wyman Rockford, Ill. 61101
72699	General Instrument Corp. Capacitor Division Newark, N.J. 07104
72982	Erie Technological Prods Inc. 644 W. 12th St. Erie, Pa. 16512
73138	Beckman Instruments, Inc. Helipot Division Fullerton, Calif. 92634
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc. Hicksville, N.Y.
73690	Elco Resistor Co. 1158 Broadway New York, N.Y.
74276	Signalite Inc. 1933 Heck Ave. Neptune, N.J. 07753
74970	Johnson, E. F., Co. 297 Tenth Ave. S.W. Waseca, Minn. 56093
75042	IRC Inc. 401 North Broad St. Philadelphia, Pa. 19108
75915	Littlefuse, Inc. 800 E. Northwest Hwy. Des Plaines, Ill. 60016
76055	Mallory Controls, Div. of Mallory P. R. & Co., Inc. Frankfort, Ind.
76493	Miller, J. W. Co. 5915 S. Main St. Los Angeles, Calif. 90003
76545	Mueller Electric Co. 1583 E. 31st St. Cleveland, Ohio 44114
77764	Resistance Products Co. 914 S. 13th St. Harrisburgh, Pa. 17104
79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.
80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139
80294	Bourns, Inc. 6135 Magnolia Ave. Riverside, Calif. 92506
81073	Grayhill, Inc. 561 Hillgrove Ave. La Grange, Ill. 60525
81483	International Rectifier Corp. 1523 East Grand Ave. El Segundo, Calif.
82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Ill. 60630
83125	General Instrument Corp. Capacitor Division Darlington, S.C. 29532
83330	Smith, Herman H., Inc. 812 Snediker Ave. Brooklyn, N.Y. 11207
83594	Burroughs Corp. Electronic Components Div. Plainfield, N.J. 07061
83701	Electronic Devices, Inc. Brooklyn, New York
84171	Arco Electronics, Inc. Community Drive Great Neck, N.Y. 11022
84411	TRW Capacitor Div. 112 W. First St. Ogallala, Nebr.
84970	Sarkes Tarzian, Inc. E. Hillside Dr. Bloomington, Ind.
86684	Radio Corp. of America Electronic Components & Devices Harrison, N.J.
87216	Philco Corp. Lansdale Div., Church Rd. Lansdale, Pa. 19446
90201	Mallory Capacitor 3029 East Washington Indianapolis, Ind. 46206
90303	Mallory Battery Co. Tarrytown, New York
91637	Dale Electronics, Inc. P.O. Box 609 Columbus, Nebr. 68601
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg. Co., Inc. 7 North Ave. Wakefield, Mass.
91802	Industrial Devices Inc. 982 River Rd. Edgewater, N.J. 07020
91929	Honeywell Inc. Micro Switch Div. Freeport, Ill. 61032
93332	Sylvania Electric Products, Inc. Semiconductor Products Div. Woburn, Mass.
93656	Electric Cord Co. 1275 Bloomfield Ave. Caldwell, N.J.
94144	Raytheon Co., Industrial Operation Components Div. Quincy, Mass.
94154	Tung-Sol Electric, Inc. Newark, New Jersey
94310	Tru-Ohm Products Memcor Components Div. Huntington, Ind. 46750
94696	Magnecraft Electric Co. 5579 North Lynch Chicago, Ill.
95348	Gordos Corp. 250 Glenwood Ave. Bloomfield, N.J. 07003
95712	Dage Electric Co., Inc. Hurricane Road Franklin, Ind.
97933	Raytheon Co. Components Div. Semiconductor Operation Mountain View, Calif.
99120	Plastic Capacitors, Inc. 2620 N. Clybourn Ave. Chicago, Ill.

LTR	ECO NO	REVISION	DATE



NOTE:

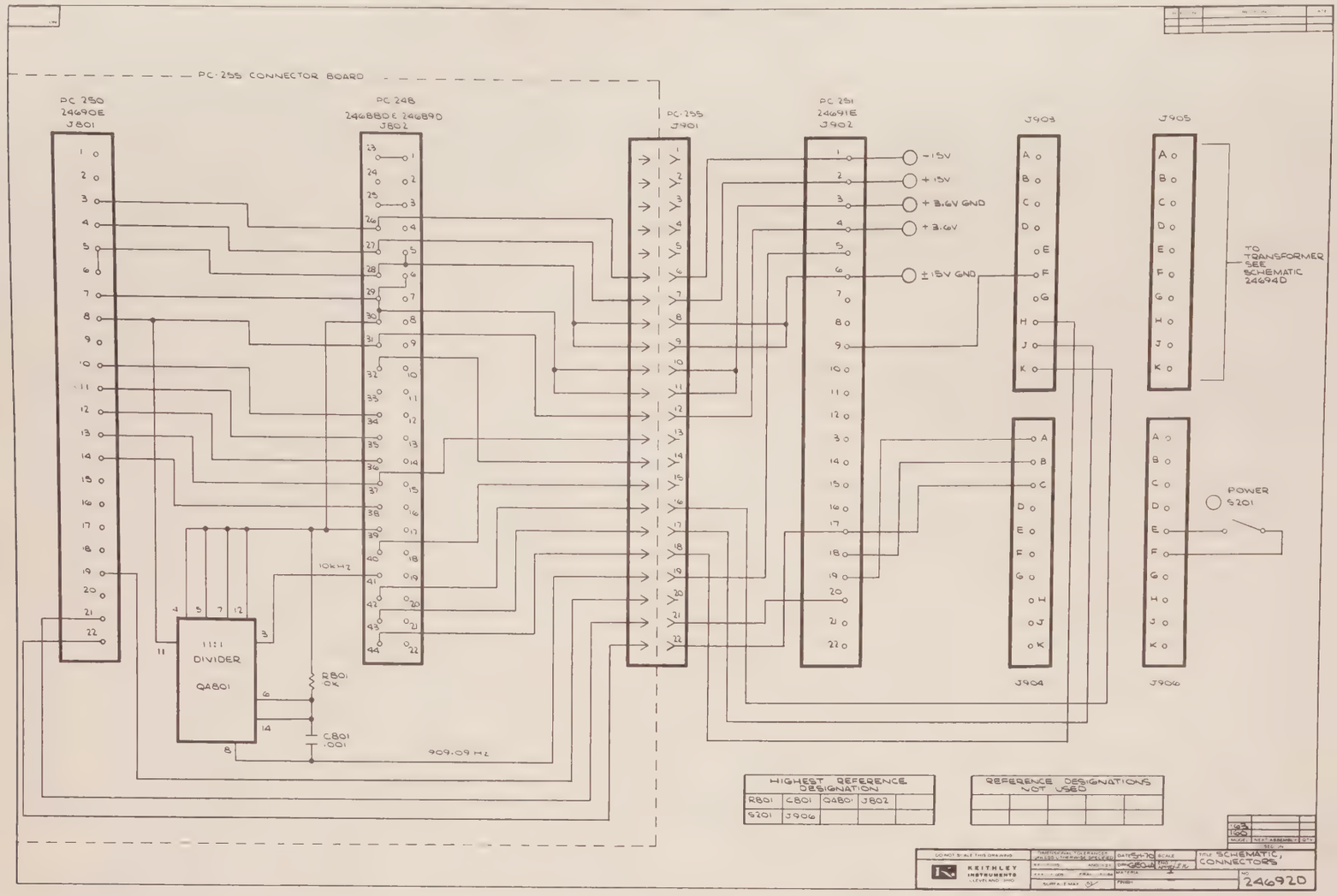
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. REAR PANEL ADJ.
4. M MEGOHM
5. K 1000 OHMS
6. pF PICOFARAD
7. CLOCKWISE ROTATION
8. * INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.
9. JUMPERS CLIPPED DURING FINAL CALIBRATION IF NECESSARY.

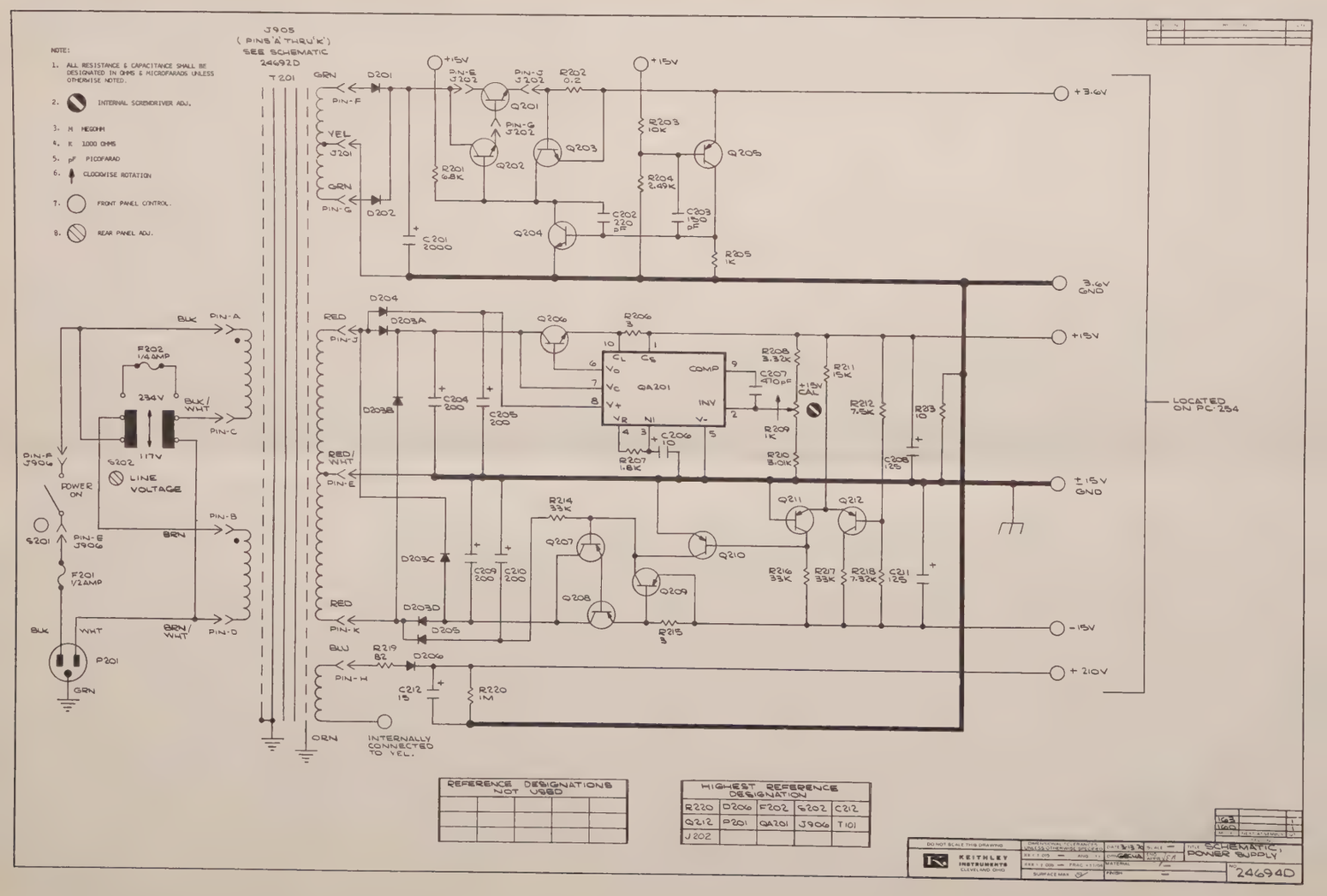
HIGHEST SCHEMATIC DESIGNATIONS					
R521	C504	DS501	J902	D502	
R611	C605	D601	Q603		
R747	C720	D702	Q708	QA704	

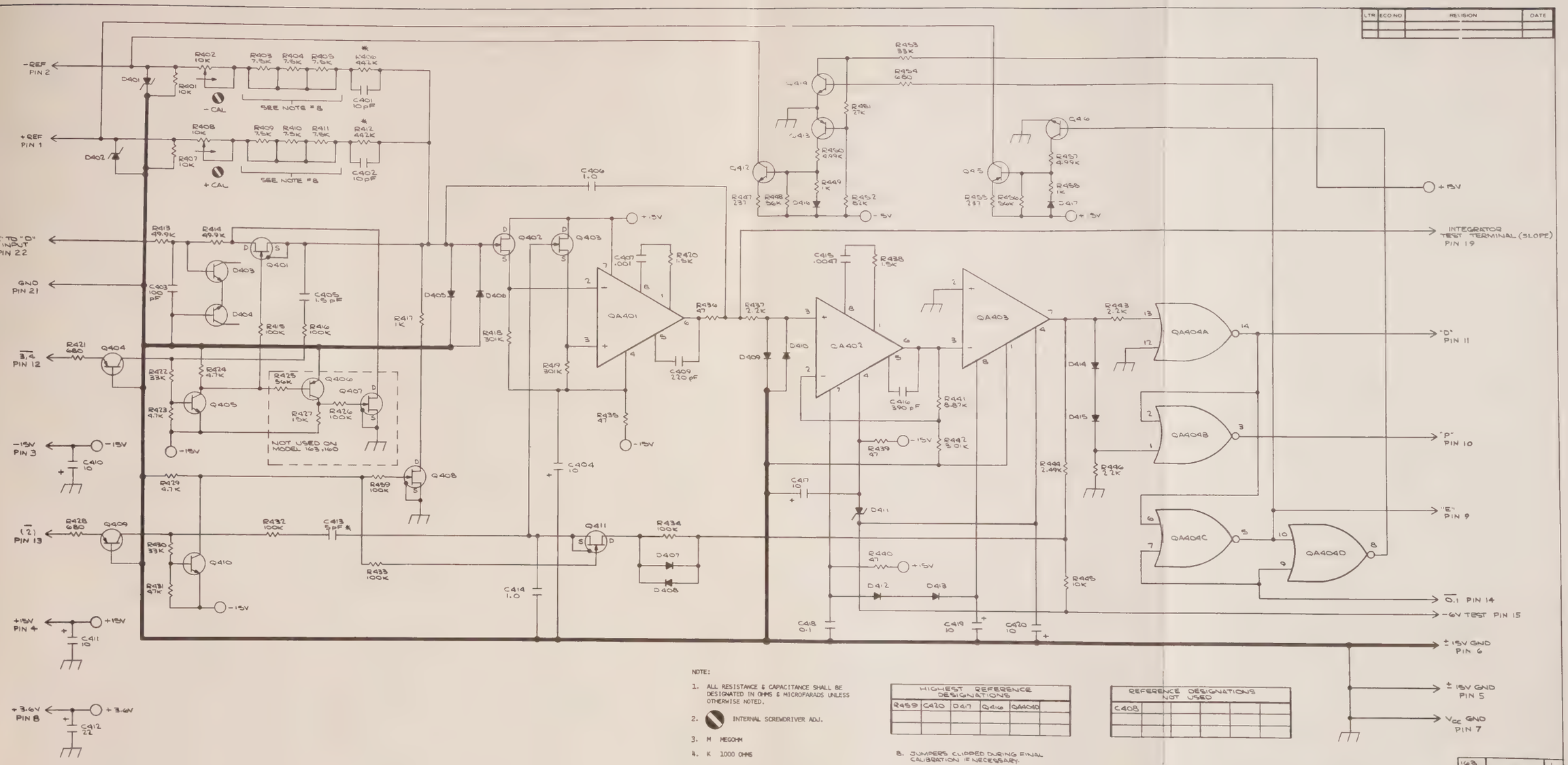
SCHEMATIC DESIGNATIONS NOT USED					
C701					
R507					
J901					

168		
169		
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 6-19-70	SCALE	TITLE SCHEMATIC, ANALOG AMPLIFIER PC-254
KEITHLEY INSTRUMENTS CLEVELAND OHIO	XX = ± .015 — ANG = ±1°	DRN GEC 4.0	ENG APPR	
	XXX = ± .008 — FRAC = ±1/64	MATERIAL —		NO 24691E
	SURFACE MAX 63	FINISH —		


PC-255 CONNECTOR BOARD
PC 250
24690E
J801
PC 248
24688D E 24689D
J802
PC-255
J901
PC 251
24691E
J902
J903
J905
J904
J906
TO TRANSFORMER SEE SCHEMATIC 24694D
-15V
+15V
+3.6V GND
+3.6V
±15V GND
POWER
S201
10KHZ
DIVIDER
QA801
R801
0K
C801
.001
909.09 HZ
HIGHEST REFERENCE DESIGNATION
R801 C801 QA801 J802
S201 J906
REFERENCE DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, CONNECTORS
NO 24692D


NOTE:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHMS
5. pF PICOFARAD
6. CLOCKWISE ROTATION
7. FRONT PANEL CONTROL.
8. REAR PANEL ADJ.
J905 (PINS 'A' THRU 'K') SEE SCHEMATIC 24692D
T201
F202 1/4AMP
234V
117V
BLK/WHT
S202 LINE VOLTAGE
POWER ON
S201
F201 1/2AMP
P201
BLK
WHT
GRN
BRN/WHT
BRN
BLU
ORN
RED
RED/WHT
YEL
GRN
D201
D202
D203A
D203B
D203C
D203D
D204
D205
D206
+15V
+3.6V
3.6V GND
-15V
+210V
±15V GND
LOCATED ON PC-254
Q201
Q202
Q203
Q204
Q205
Q206
Q207
Q208
Q209
Q210
Q211
Q212
QA201
R201 6.8K
R202 0.2
R203 10K
R204 2.49K
R205 1K
R206 3
R207 1.8K
R208 3.32K
R209 1K
R210 3.01K
R211 15K
R212 7.5K
R213 10
R214 33K
R215 3
R216 33K
R217 33K
R218 7.32K
R219 82
R220 1M
C201 2000
C202 220 pF
C203 150 pF
C204 200
C205 200
C206 10
C207 470pF
C208 125
C209 200
C210 200
C211 125
C212 15
+15V CAL
REFERENCE DESIGNATIONS NOT USED
HIGHEST REFERENCE DESIGNATION
R220 D206 F202 S202 C212
Q212 P201 QA201 J906 T101
J202
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, POWER SUPPLY
NO 24694D



LTR	ECO NO	REVISION	DATE

NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHMS
5. pF PICOFARAD
6. CLOCKWISE ROTATION
7. * INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.

HIGHEST REFERENCE DESIGNATIONS				
R459	C420	D417	Q416	QA404D

REFERENCE DESIGNATIONS NOT USED						
C408						

8. JUMPERS CLIPPED DURING FINAL CALIBRATION IF NECESSARY.

163		1
160		
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

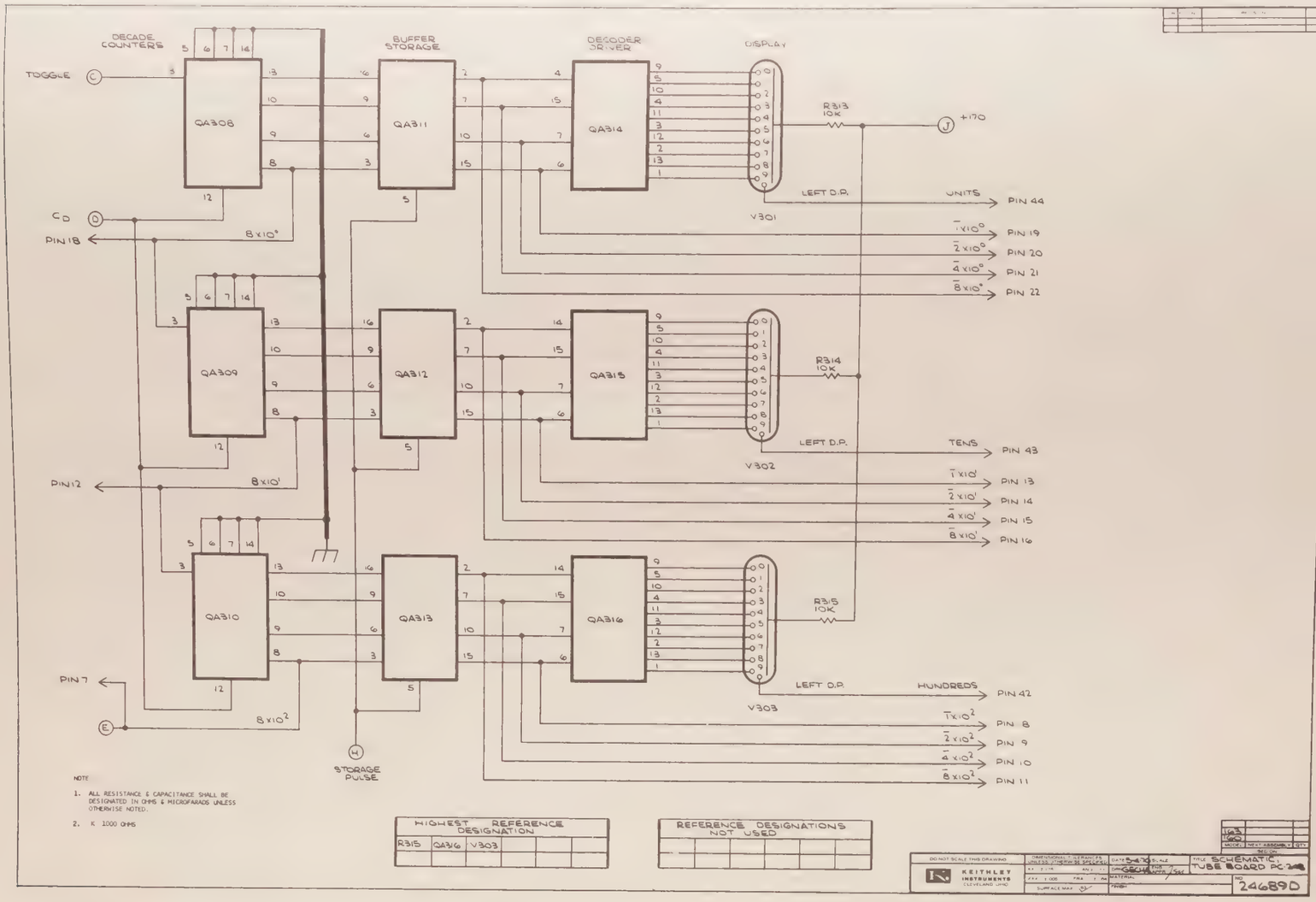
KEITHLEY INSTRUMENTS CLEVELAND OHIO

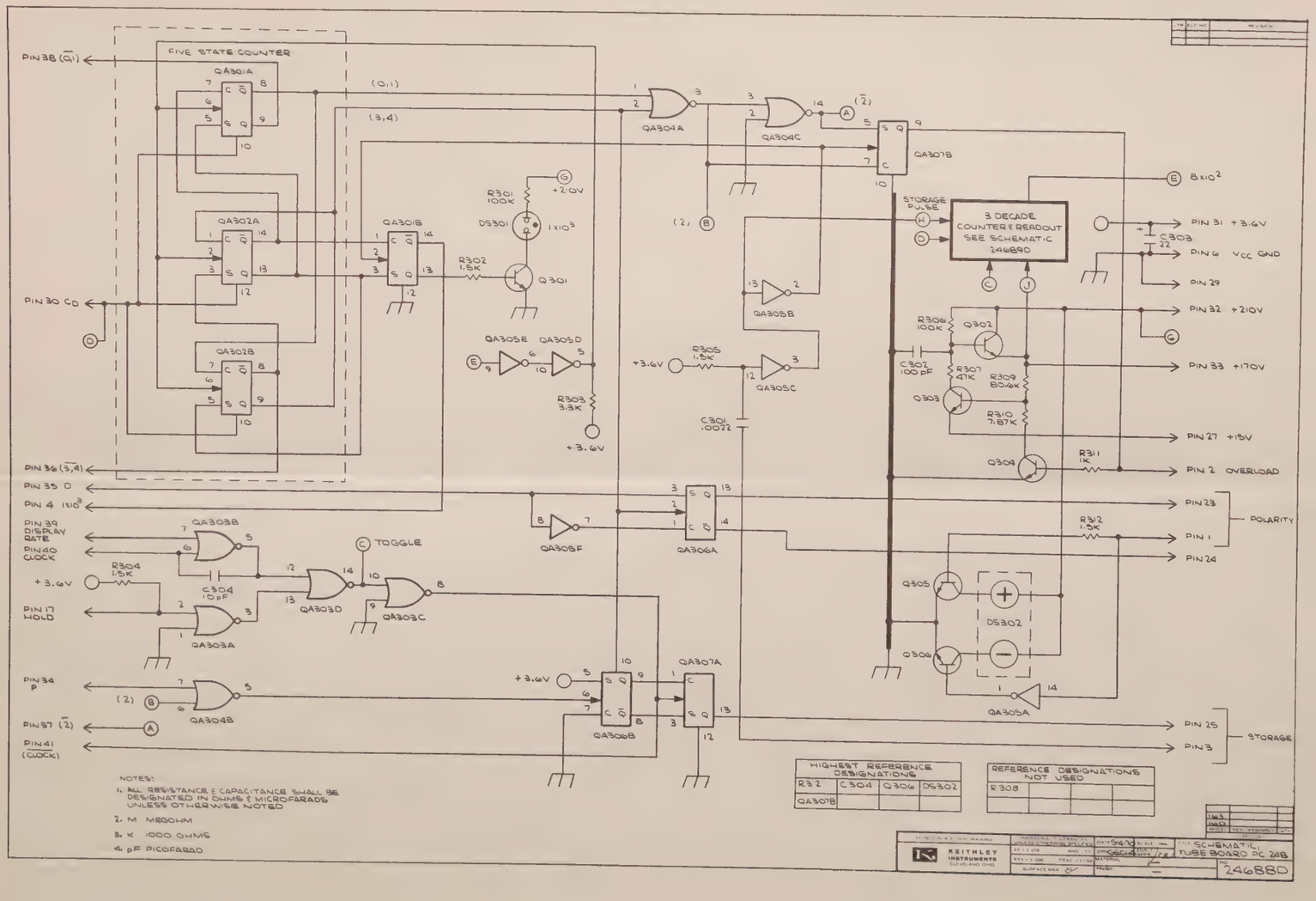
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ± .015 — ANG = ± 1°
XXX = ± .005 — FRAC = ± 1/64
SURFACE MAX 63

DATE 3-21-75 SCALE —
DRN [illegible] ENG APPR. [illegible]
MATERIAL —
FINISH —

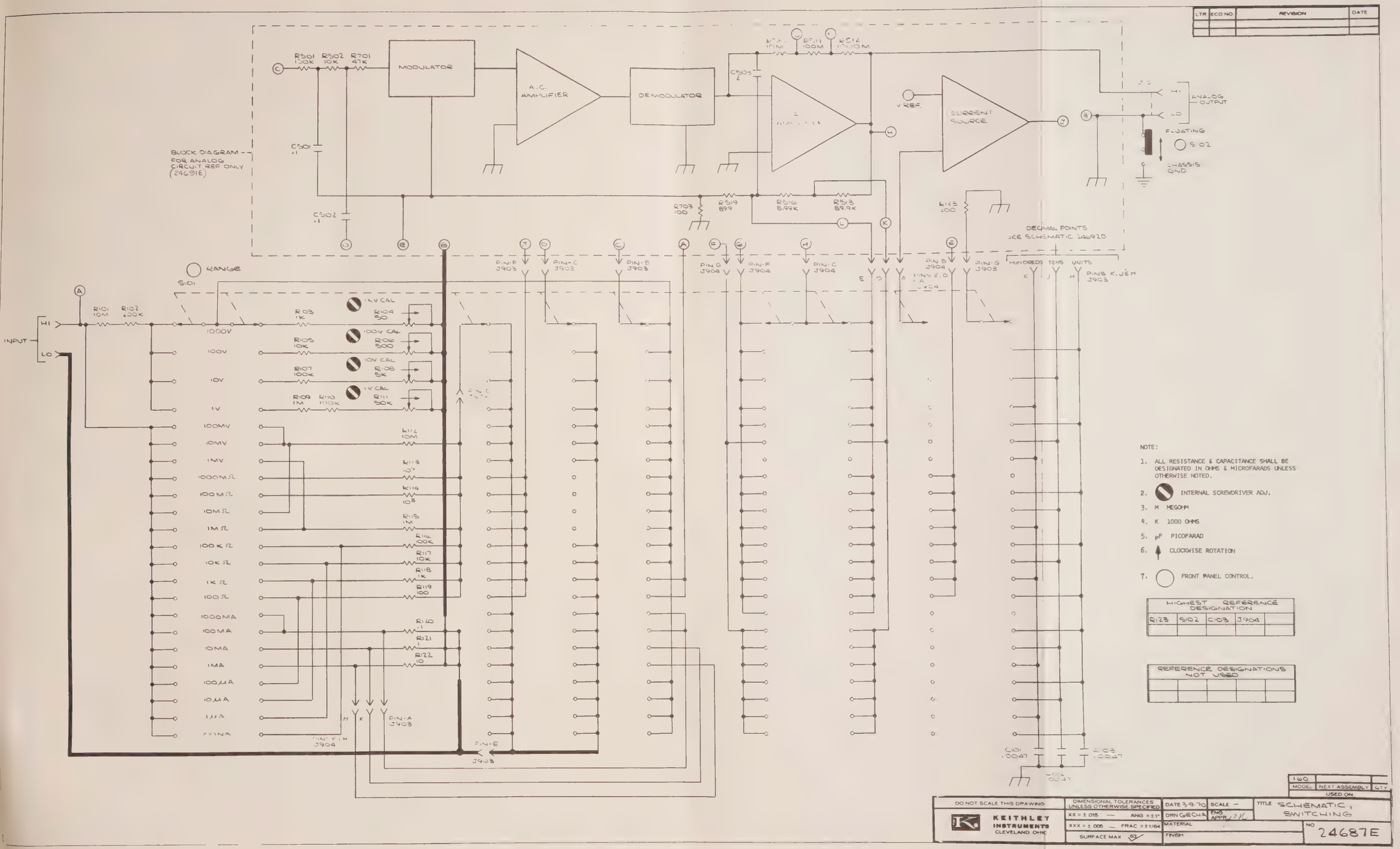
TITLE SCHEMATIC, INTEGRATOR BOARD

NO 24690E


DECADE COUNTERS
BUFFER STORAGE
DECODER DRIVER
DISPLAY
TOGGLE
QA308
QA311
QA314
QA309
QA312
QA315
QA310
QA313
QA316
R313 10K
R314 10K
R315 10K
V301
V302
V303
LEFT D.P.
UNITS
TENS
HUNDREDS
+17V
PIN 44
PIN 19
PIN 20
PIN 21
PIN 22
PIN 43
PIN 13
PIN 14
PIN 15
PIN 16
PIN 42
PIN 8
PIN 9
PIN 10
PIN 11
CD
PIN 18
PIN 12
PIN 7
8X10°
8X10¹
8X10²
STORAGE PULSE
NOTE
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K 1000 OHMS
HIGHEST REFERENCE DESIGNATION
R315 QA316 V303
REFERENCE DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC TUBE BOARD PC 248
246890


FIVE STATE COUNTER
QA301A
QA302A
QA301B
QA302B
QA304A
QA304C
QA307B
QA305B
QA305E
QA305D
QA305C
QA305F
QA306A
QA303B
QA303D
QA303C
QA303A
QA304B
QA306B
QA307A
QA305A
3 DECADE COUNTER & READOUT SEE SCHEMATIC 246890
R301 100K
R302 1.5K
R303 3.3K
R304 1.5K
R305 1.5K
R306 100K
R307 47K
R309 80.6K
R310 7.87K
R311 1K
R312 1.5K
C301 .0022
C302 100 pF
C303 22
C304 10pF
Q301
Q302
Q303
Q304
Q305
Q306
DS301
DS302
+2.0V
+3.6V
1X10³
8X10²
PIN 38 (Q,1)
PIN 30 CD
PIN 36 (3,4)
PIN 35 D
PIN 4 1X10³
PIN 39 DISPLAY RATE
PIN 40 CLOCK
PIN 17 HOLD
PIN 34 P
PIN 37 (2)
PIN 41 (CLOCK)
(0,1)
(3,4)
(2)
TOGGLE
STORAGE PULSE
PIN 31 +3.6V
PIN 6 Vcc GND
PIN 29
PIN 32 +21V
PIN 33 +17V
PIN 27 +15V
PIN 2 OVERLOAD
PIN 23
PIN 1
PIN 24
POLARITY
PIN 25
PIN 3
STORAGE
NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED
2. M MEGOHM
3. K 1000 OHMS
4. pF PICOFARAD
HIGHEST REFERENCE DESIGNATIONS
R32 C304 Q306 DS302
QA307B
REFERENCE DESIGNATIONS NOT USED
R308
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC TUBE BOARD PC 248
246880

LTR	ECO NO	REVISION	DATE



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHMS
5. pF PICOFARAD
6. CLOCKWISE ROTATION
7. FRONT PANEL CONTROL.

HIGHEST REFERENCE DESIGNATION				
R123	S102	C103	J904	

REFERENCE DESIGNATIONS NOT USED				

160		
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

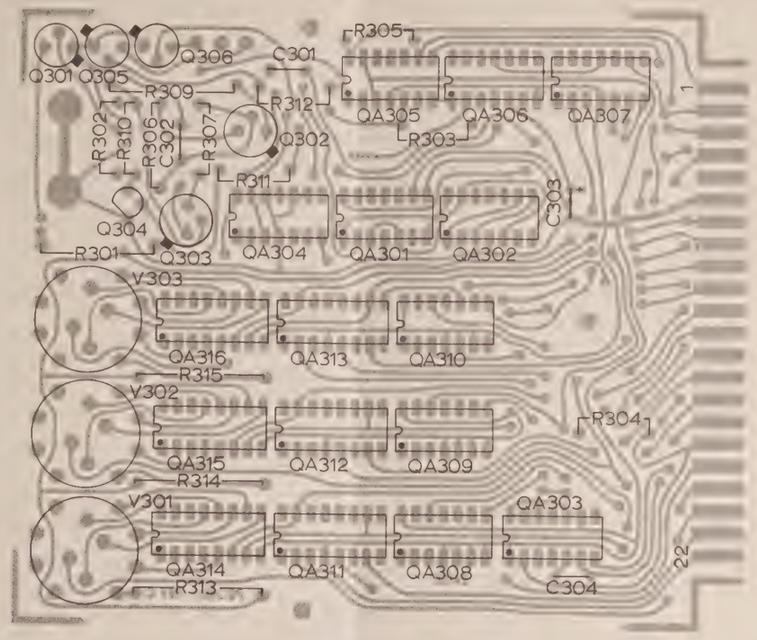
KEITHLEY INSTRUMENTS CLEVELAND OHIO

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ± .015 — ANG = ±1°
XXX = ± .005 — FRAC = ±1/64
SURFACE MAX 63

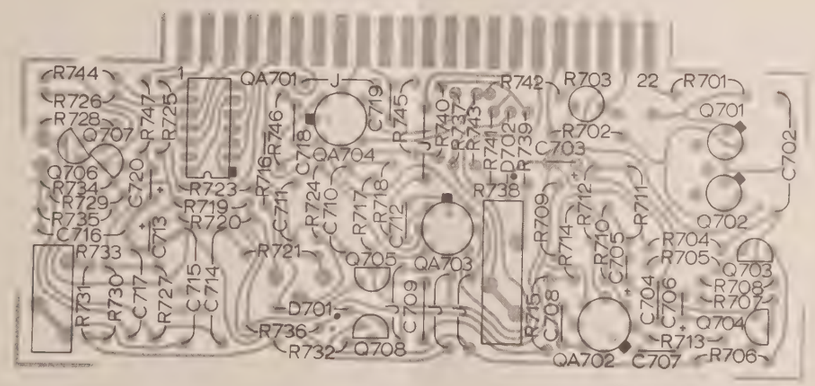
DATE 3-9-70 SCALE —
DRN GECHA ENG APPR
MATERIAL
FINISH

TITLE SCHEMATIC, SWITCHING

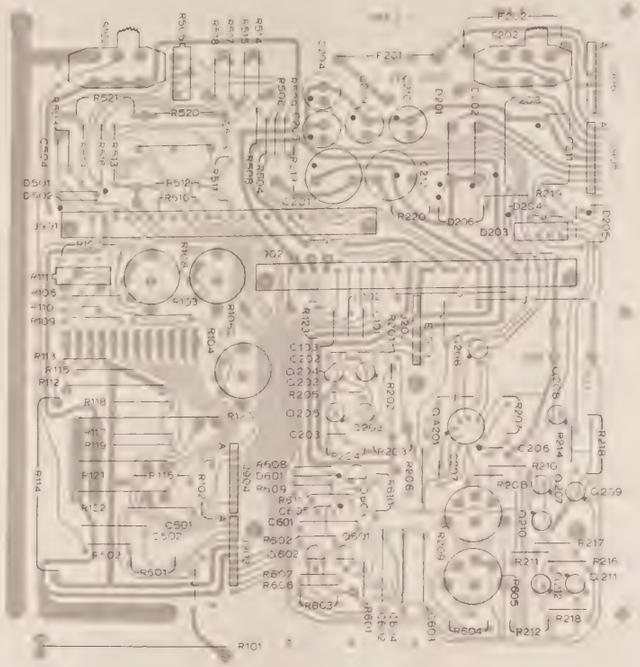
NO 24687E



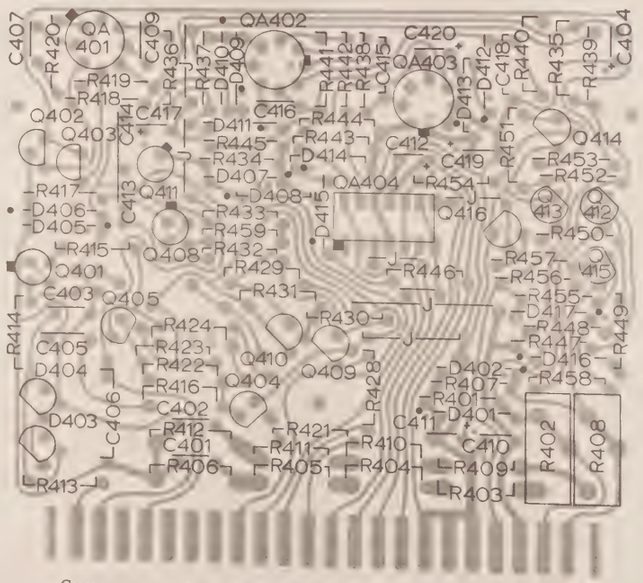
Component Layout, PC-248 (Tube Board).
Circuit pattern on component side has been omitted for clarity.



Component Layout, PC-251 (Analog Amplifier).



Component Layout, PC-254 (Mother Board).



Component Layout, PC-250 (Integrator Board).

GENERAL INSTRUCTIONS

a. Installation. The Model 1602 Digital Output Option is available either factory or field installed in a Model 160 Digital Multimeter or a Model 163 Digital Voltmeter.

b. Connections. Digital BCD Outputs and controls are provided through a 50-pin PRINTER/CONTROL receptacle (J1006) installed on the rear panel. A mating connector can be purchased separately by ordering Keithley Part No. CS-220. An accessory Terminal Box can be purchased separately by ordering Keithley Model 4405. This terminal box has a mating connector, a three foot cable, and a 50-terminal barrier strip for quick connections to a digital recorder or computer. The buffer stages utilize "Open Collector" output transistors. Therefore, the user must supply a pull-up resistor and external voltage for each buffered output as shown in the Instruction Manual, page 8, Figure 5. The individual outputs are identified on page 9, Table 2-8.

c. Schematics and Parts List. The schematic (No. 24685D) for the 1602 Digital Output Option is on page 4 of this Instruction Sheet.

d. Operation.

1. Specifications. The overall specifications for the 1602 showing the 1602 operation are given in the Model 160 Instruction Manual, page 8, Table 2-7.

2. Timing Diagram. A timing diagram showing the 1602 operation is given on page 9, Figure 6.

3. Block Diagram. A composite block diagram of the 160 A/D converter and the 1602 option is given on page 13, Figure 9.

4. Strobe. The strobe control is activated by connecting pin 49 to ground. Closure to ground enables conduction. Open circuit to ground inhibits all output lines from conducting.

5. Hold. The remote hold is activated by connecting pin 47 to ground. Closure to ground retains result of last conversion in both the output register and the display.

REPLACEABLE PARTS LIST

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
C1001	1.2 µF	20 V	ETT	17554	TSD1-20	C179-1.2M
C1002	.001 µF	600 V	CerD	72982		C22-.001M
C1003	.0022 µF	600 V	CerD	72982		C22-.0022M

CONNECTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
J1001	Receptacle, 10-Pin	22526	20052	CS-237
J1002	Receptacle, 10-Pin	22526	20052	CS-237
J1003	Receptacle, 10-Pin	22526	20052	CS-237
J1004	Receptacle, 44-Pin	09922	PSC4DD2212	CS-205
J1005	Receptacle, 22-Pin	09922	PSC4SS2212	CS-182
J1006	Receptacle, 50-Pin	02660	57405001	CS-221
	Plug, Mate of J1006, (Not Supplied)	02660	57305001	CS-220

REPLACEABLE PARTS LIST (Cont'd)

DIODES

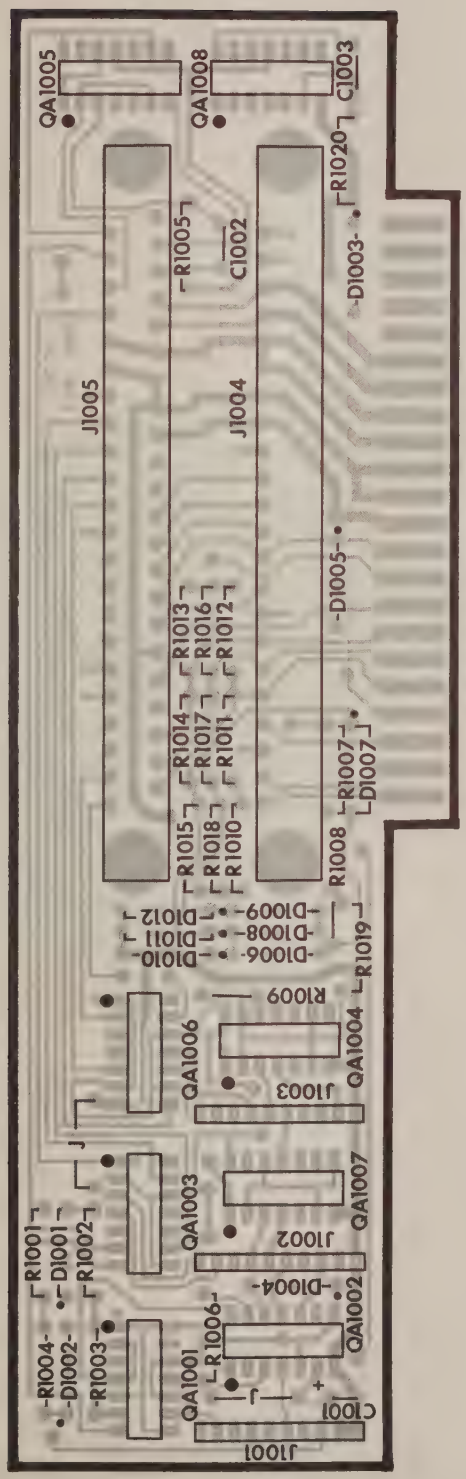
Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
D1001	Germanium	15238	1N87	RF-39
D1002	Germanium	15238	1N87	RF-39
D1003	Germanium	15238	1N87	RF-39
D1004	Germanium	15238	1N87	RF-39
D1005	Germanium	15238	1N87	RF-39
D1006	Silicon	01295	1N914	RF-28
D1007	Silicon	01295	1N914	RF-28
D1008	Silicon	01295	1N914	RF-28
D1009	Silicon	01295	1N914	RF-28
D1010	Silicon	01295	1N914	RF-28
D1011	Silicon	01295	1N914	RF-28
D1012	Silicon	01295	1N914	RF-28

INTEGRATED CIRCUITS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
QA1001	Quad, NAND Gate	04713	MC858P	IC-22
QA1002	Quad, NAND Gate	04713	MC858P	IC-22
QA1003	Quad, NAND Gate	04713	MC858P	IC-22
QA1004	Quad, NAND Gate	04713	MC858P	IC-22
QA1005	-	04713	MC887P	IC-23
QA1006	Quad, NAND Gate	04713	MC858P	IC-22
QA1007	Quad, NAND Gate	04713	MC858P	IC-22
QA1008	Binary Counter	04713	MC877P	IC-21

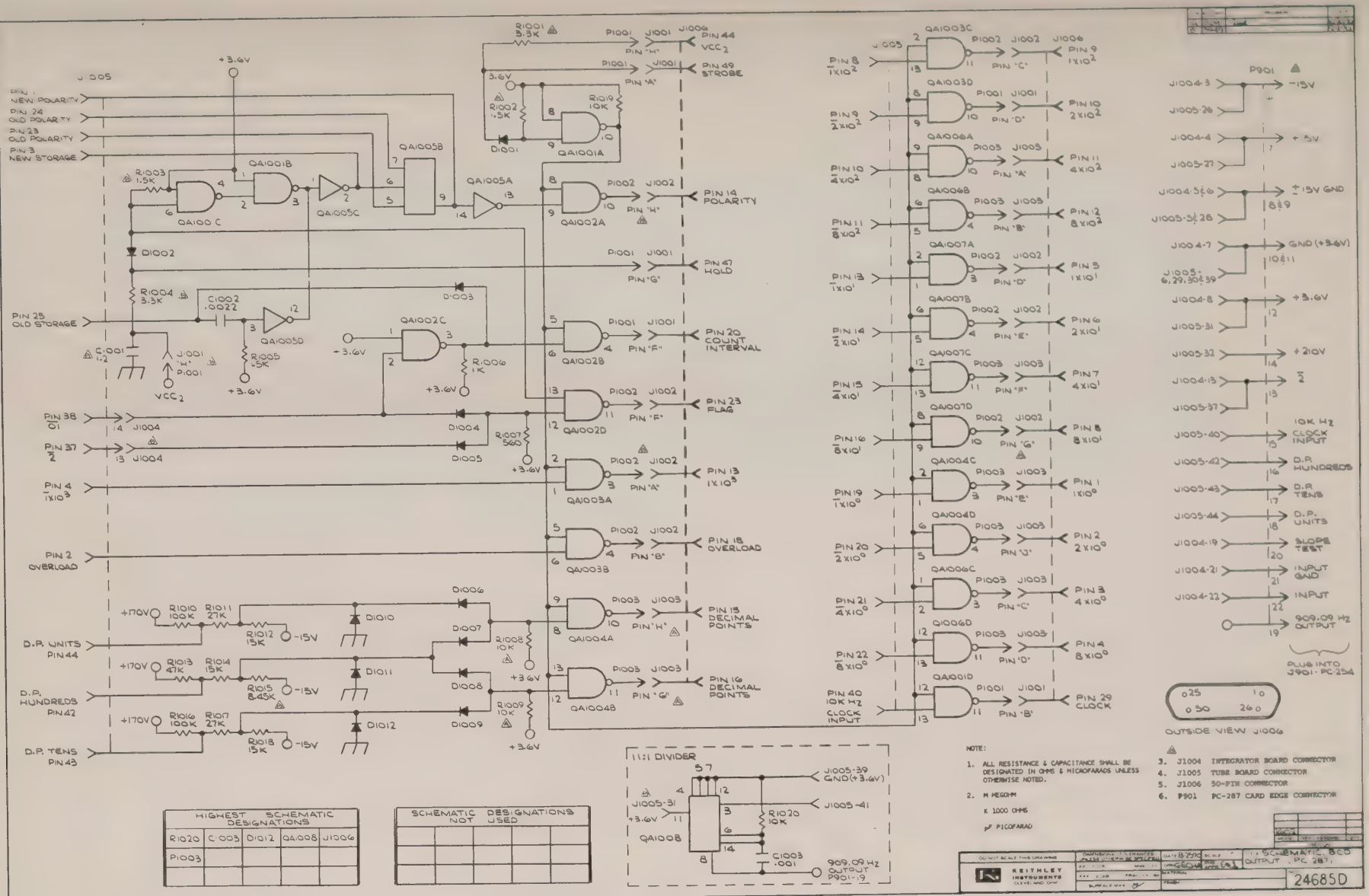
RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
R1001	3.3 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K
R1002	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K
R1003	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K
R1004	3.3 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K
R1005	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K
R1006	1 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K
R1007	560 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-560
R1008	10 KΩ	10%, 1/8 W	Comp	01121	BB	R143-10K
R1009	10 KΩ	10%, 1/8 W	Comp	01121	BB	R143-10K
R1010	100 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K
R1011	27 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-27K
R1012	15 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K
R1013	47 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K
R1014	15 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K
R1015	8.45 KΩ	1%, 1/8 W	MtF	07716	CEA	R88-8.45K
R1016	100 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K
R1017	27 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-27K
R1018	15 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K
R1019	10 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K
R1020	10 KΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K



Component Designations, PC-287.

(Circuit pattern on component side has been omitted for clarity.)



HIGHEST SCHEMATIC DESIGNATIONS				
R1020	C 003	D1012	QA1008	J1006
P1003				

SCHEMATIC DESIGNATIONS NOT USED				

NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. M MEGOHM
   K 1000 OHMS
   pF PICOFARAD
3. J1004 INTEGRATOR BOARD CONNECTOR
4. J1005 TUBE BOARD CONNECTOR
5. J1006 50-PIN CONNECTOR
6. P901 PC-287 CARD EDGE CONNECTOR

KEITHLEY INSTRUMENTS CLEVELAND OHIO

SCHEMATIC, BCD OUTPUT, PC 287.

24685D

REPAIR AND CALIBRATION FORM

For repair or calibration, please fill out this form and return it with your instrument to:

Sales Service Department
Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

R-_____
Do not write in this space.

User's Name _____ Telephone _____ Ext. _____
Company _____ Address _____
Division _____ City _____ State _____ Zip _____
Date _____ Model No. _____ Serial No. _____

1. Reason for Return
   - ☐ Repair and Recalibration
   - ☐ Recalibration only (No report, except as specified in item 4 on reverse)*

   *If repairs are necessary to meet specifications, they will be in addition to the calibration.

2. Calibration Report Desired
   - ☐ Report of Calibration Certified Traceable to N.B.S.
   - ☐ Calibration Report
   - ☐ Certificate of Compliance
   - ☐ None

   (for details, see reverse side of this form)

3. To help repair the instrument, briefly describe the problem: _____

4. Is the problem ☐ Constant ☐ Intermittant
   Under what conditions does the problem occur:
   a) Control setting _____
   b) Approx. Temperature _____ °F
   c) Approx. Temperature variation ± _____ °F
   d) Approx. Humidity (high, medium, low) _____
   e) Line voltage _____
   f) Other (such as line transients, line variations, etc.) _____

5. Please draw a block diagram of the system using the Keithley. List any other pertinent data which can help in the repair. Include charts or other data if available.
   Signal Source _____
   Source Impedance _____
   Readout Device:
   - ☐ Recorder
   - ☐ Oscilloscope
   - ☐ Other
   - ☐ None

   Lengths & Types of Connecting Cables _____

6. What repairs or modifications have been made on this instrument which are not on file with the Keithley Repair Department? _____

7. Please enclose any other pertinent data and charts which you feel might help the Repair and Calibration Department

_____ Signature _____ Title

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CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS.

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

1. Report of Calibration Certified Traceable to the National Bureau of Standards.

This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

As of 11/1/69 the Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	$275	Model 5155 (Complete Set)	$295
Model 260	$225	Model 5155-10^{8}	$ 50
Model 261	$375	Model 5155-10^{9}	$ 50
Model 515	$375	Model 5155-10^{10}	$ 50
Model 630	$275	Model 5155-10^{11}	$ 60
Model 660A	$250	Model 5155-10^{12}	$ 60
Model 662	$275	Model 5155-10^{13}	$ 80

2. Calibration Report.

This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

This report is available for any instrument in our line. As of November 1, 1969, only the following price has been established for this report:

Model 261 . . . . . $ 55

Prices for other units can be estimated upon request.

3. Certificate of Compliance.

This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The $55 charge is incorporated as part of the normal calibration charge of the Model 261.

4. Recalibration.

This is a recalibration of the instrument according to our factory calibration procedures. The prices for this as of November 1, 1969 are as follows:

Model 260 . . . . . $ 85 (No report supplied. A Certificate of Compliance can be had at no charge if requested).

Model 261 . . . . . $ 55 (Calibration Report as described in (2) above is supplied. See (3) for explanation).

All other instruments are on a time and material basis for the particular unit involved.

CHANGE NOTICE

KEITHLEY INSTRUMENTS, INC.
INSTRUCTION MANUAL
MODELS 160/163

0971

NOTICE: Since Keithley Instruments is continually improving product performance and reliability it is often necessary to make changes to Instruction Manuals to reflect these improvements. The change* to the instrument consists of an added front panel terminal identified as CASE and a shorting link between LO and CASE. The front panel CASE terminal and shorting link permits the user to select either grounded or floating operation with visual indication of the selected mode. Since the shorting link is used for changing from float to ground modes the rear panel selector switch has been deleted. The following changes will update the manual to make it agree with the modified version of the instrument.

SECTION 1. GENERAL DESCRIPTION.

Page 2: Add the following to Table 1-2.

Control	Functional Description
Chassis Terminal	Connects chassis to Low when shorting link is installed.

Page 2: Delete the reference to "LO" Switch (S102). To Float the instrument, remove the shorting link between the black and green terminals on the front panel.

Page 3: Delete the reference to "LO" Switch (S102) shown in Figure 3.

SECTION 2. OPERATION.

Page 4: Revise paragraph 2-1a as follows:

Binding Post Terminals. Three binding posts are provided on the front panel for all input connections. The terminals are color coded as follows: Red = Input High, Black = Input Low, Green = Chassis Ground (CASE).

Page 5: Delete the reference to "LO" Switch (S102) in paragraph 2-3a.

Page 7: Revise paragraph 2-9 as follows:

a. The low terminal (black) can be floated above chassis (CASE terminal) by removing the shorting link between the black and green terminals.

b. The instrument chassis should be connected to earth ground via the front panel "CASE" terminal or the "GROUND" pin on the 3-prong AC POWER receptacle.

SCHEMATICS: Switching schematic 24687E has been revised to reflect the circuit changes described above.

* Effective for instrument serial numbers starting 82269.

KEITHLEY INSTRUMENTS, INC.

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY